SIMPLICITY STUDIO C8051F85X WALKTHROUGH

1. Introduction

This document provides a step-by-step walkthrough that shows how to develop a basic embedded project using Simplicity Studio (IDE and Configurator) to run on the C8051F850 ToolStick Daughter Card (**TOOLSTICK850-DC**). The same steps can be applied to develop a project to run on the C8051F850 UDP MCU card (**UPMU-F850 MCU**). The project uses a potentiometer sampled via the ADC to control the brightness of an LED by controlling the duty cycle of an output pin using the PWM. Simplicity Configurator will be used to generate hardware initialization code for hardware peripherals, and Simplicity IDE will be used to develop, build, download, and debug the firmware project.

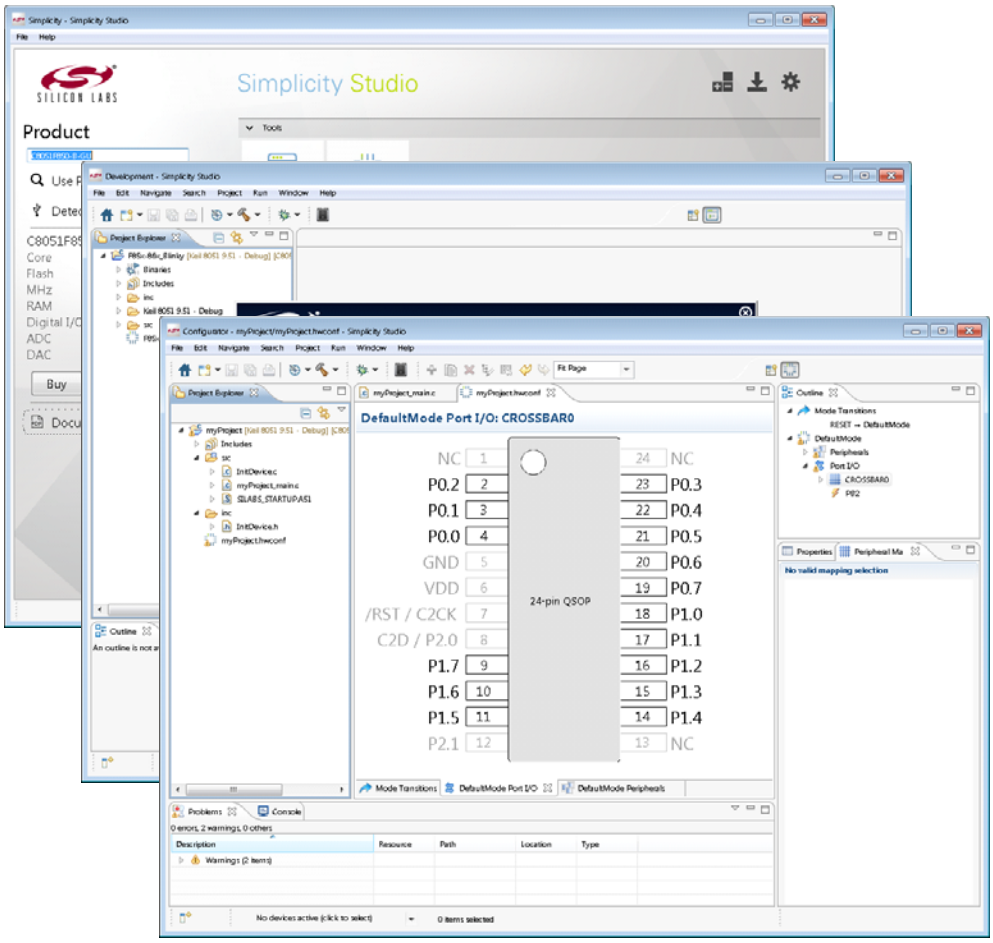

Figure 1. Simplicity Studio—IDE and Configurator Walkthrough

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2. Relevant Documents

- **Simplicity IDE Guide**—In Simplicity IDE, select **Help→Help Contents** to display the *Simplicity IDE Guide* as well as any installed documentation, including data sheets and user's guides.
- **Simplicity Configurator Guide**—In the Simplicity IDE, select **Help→Help Contents** to display this guide.
- **AN0822: *Simplicity Studio User's Guide***—In addition to the documentation within the tool itself, this document provides a discussion of the Simplicity Studio tool. Application Notes are available on www.silabs.com/32bit-appnotes and www.silabs.com/8bit-appnotes.
- **AN0823: *Simplicity Configurator User's Guide***—In addition to the documentation within the tool itself, this document provides a discussion of the Simplicity Configurator tool. Application Notes are available on www.silabs.com/32bit-appnotes and www.silabs.com/8bit-appnotes.
- **C8051F850 Data Sheet—**http://www.silabs.com/products/mcu/smallmcu/pages/c8051f85x-86x.aspx (Documentation Tab)

3. Installing Simplicity Studio

1. Download and install Simplicity Studio from www.silabs.com/8bit-software or www.silabs.com/simplicity-studio.
2. Run Simplicity Studio by selecting **Start→Silicon Labs→Simplicity Studio→Simplicity Studio** from the start menu or double-clicking the **Simplicity Studio** shortcut on the desktop.
3. The **Installation Setup** wizard automatically runs after Simplicity Studio starts. To manually start the **Installation Setup** wizard, click the **Add/Remove** button on the top-right corner of the application.
4. Follow the instructions to install the software. The **Full** installation will include support both 8051 and EFM32 products. Choose the **8051** option for a reduced installation set.
5. The first time the project creation wizard runs, the **Setup Environment** wizard will guide the user through the process of configuring the build tools and SDK selection.
6. Simplicity Studio can detect if certain toolchains are not activated. If the **Licensing Helper** is displayed after completing the **Setup Environment** wizard, follow the instructions to activate the toolchain.

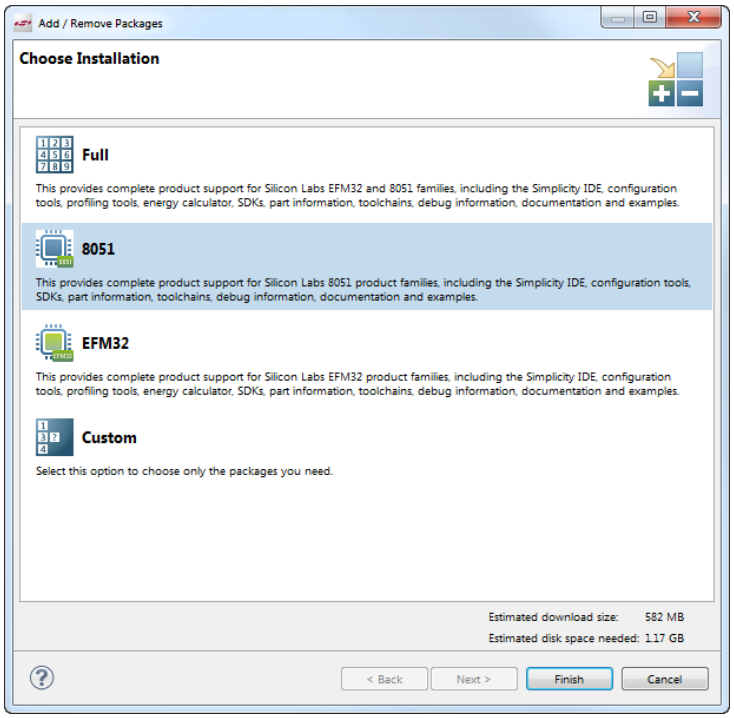

Add / Remove Packages
Choose Installation
Full
This provides complete product support for Silicon Labs EFM32 and 8051 families, including the Simplicity IDE, configuration tools, profiling tools, energy calculator, SDKs, part information, toolchains, debug information, documentation and examples.
8051
This provides complete product support for Silicon Labs 8051 product families, including the Simplicity IDE, configuration tools, SDKs, part information, toolchains, debug information, documentation and examples.
EFM32
This provides complete product support for Silicon Labs EFM32 product families, including the Simplicity IDE, configuration tools, profiling tools, energy calculator, SDKs, part information, toolchains, debug information, documentation and examples.
Custom
Select this option to choose only the packages you need.
Estimated download size: 582 MB
Estimated disk space needed: 1.17 GB
< Back
Next >
Finish
Cancel

Figure 2. Installing Simplicity Studio

4. Hardware Setup

Setup the C8051F850 ToolStick hardware:

Figure 3. Hardware Setup Diagram

1. Verify that the shorting block on JP1 is installed on the TOOLSTICK850-DC daughter card.
2. Connect the daughter card to the ToolStick Base Adapter.
3. Connect one end of the USB extension cable to the ToolStick Base Adapter and connect the other end to a PC. The USB connection provides power to the ToolStick Debug Adapter and daughter card. The ToolStick Debug Adapter can be used to write to the C8051F850 flash and to enable on-chip debug support.

5. Software Setup

Install Simplicity Studio as described in "3. Installing Simplicity Studio" on page 2, select a **Typical** or **8051** installation. Select the **C8051F85x/86x** devices in the **Part Selection** window.

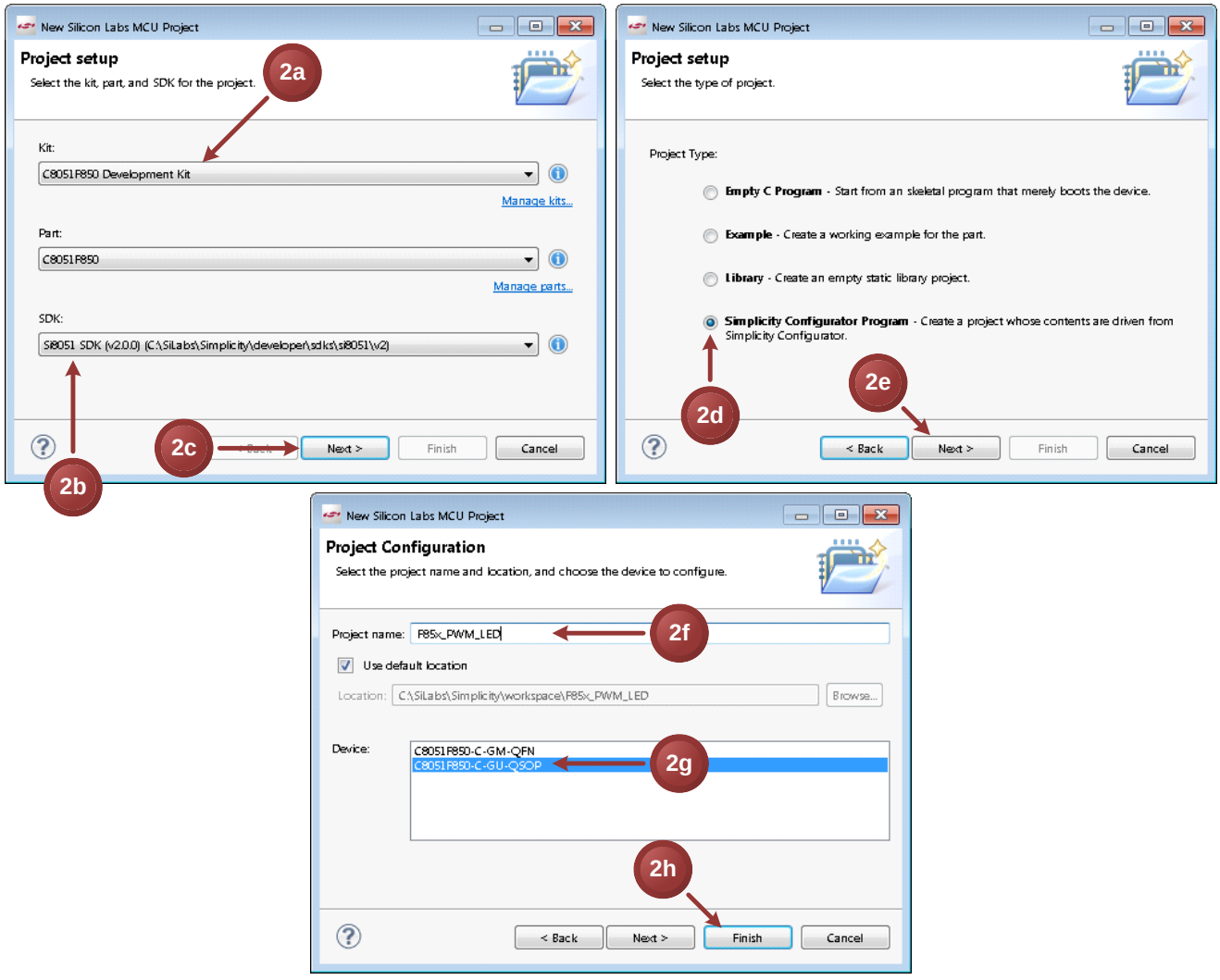
6. Using Configurator to Pulse Width Modulate (PWM) an LED

The PWM LED project uses a potentiometer sampled by the ADC to control the brightness of an LED by controlling the duty cycle of an output pin using the Programmable Counter Array (PCA) to generate a PWM waveform.

After configuring the Simplicity IDE, the next step is to create a new project using the **New Silicon Labs MCU Project** wizard. Each project has its own source files, target configuration, SDK configuration, and build configurations such as the Debug and Release build configurations. The IDE can be used to manage multiple projects in a collection called a workspace. Workspace settings are applied globally to all projects within the workspace. This can include settings such as key bindings, window preferences, and code style and formatting options. Project actions, such as build and debug are context sensitive. For example, the user must select a project in the **Project Explorer** view in order to build that project.

Create a new Silicon Labs MCU Project called **F85x_PWM_LED**:

1. Create a new project by selecting **File→New→Silicon Labs MCU Project** from the menu bar.
2. Complete the **New Silicon Labs MCU Project** wizard:
   a. In the **Project setup** step, select **C8051F850 Development Kit** from the **Kit** combo box. This will automatically select the **C8051F850** part in the **Part** combo box.
   b. Select **Si8051 SDK (v2.0.0)** from the **SDK** combo box.
   c. Click the **Next** button.
   d. Select the **Simplicity Configurator Program** radio button from the **Project Type** list. Simplicity Studio Configurator generates hardware initialization code using a graphical interface.
   e. Click the **Next** button.
   f. In the **Project Configuration** step, enter **F85x_PWM_LED** in the **Project Name** text box.
   g. Select the **C8051F850-C-GU-QSOP** device from the **Device** list box.
   h. Click the **Finish** button.



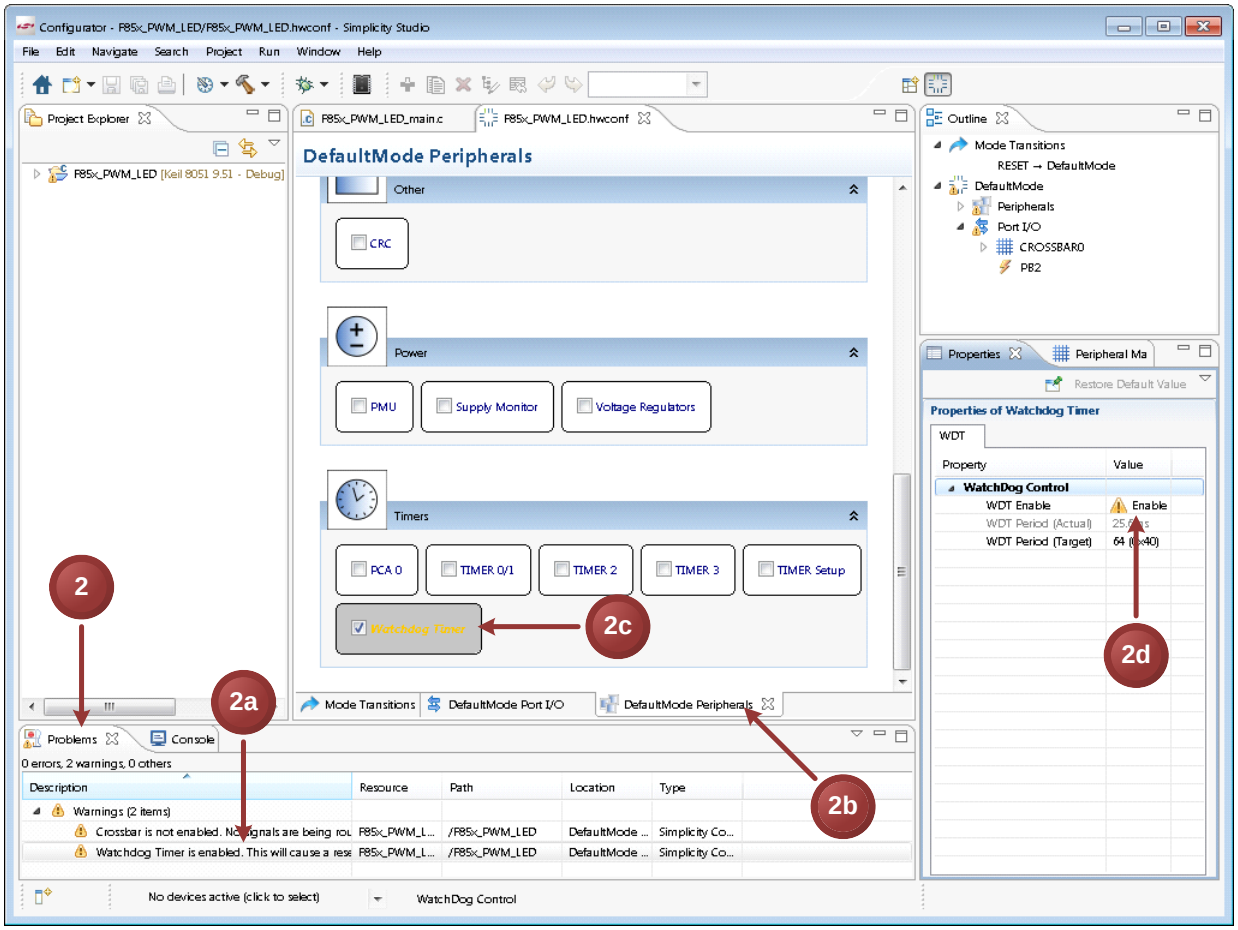
Simplicity Studio Configurator greatly simplifies MCU peripheral initialization by presenting peripherals and peripheral properties in a graphical user interface. The majority of the initialization firmware can be generated by selecting peripherals and selecting property values from combo boxes or entering register values in text boxes.

Some peripherals provide calculators such as baud rate calculators, timer overflow rate calculators, and SPI clock rate calculators that can be used to automatically calculate the necessary reload register value to generate the clock rate specified by the user. Configurator also provides real-time validation of properties to ensure that a configuration is valid before downloading code to the MCU.

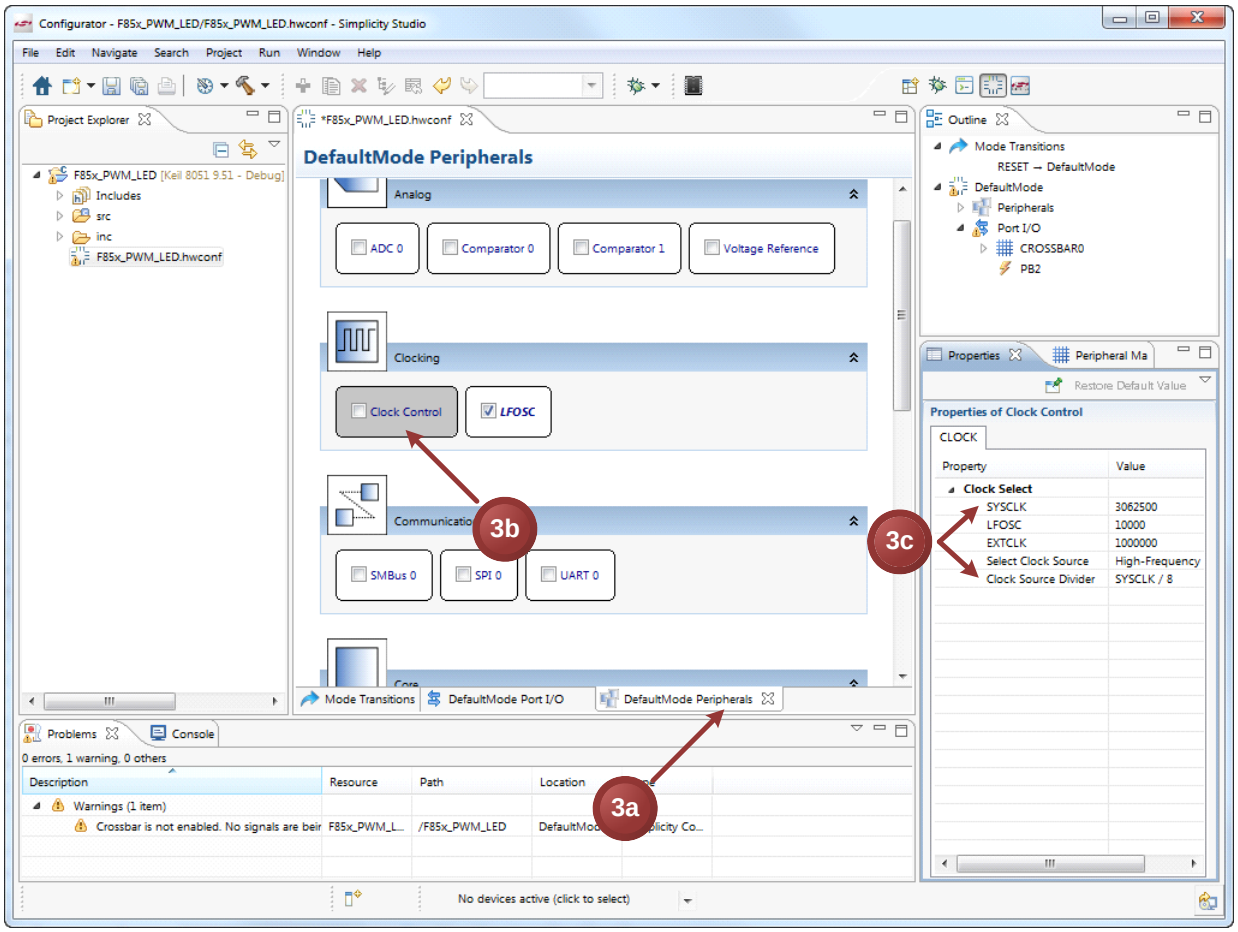
The following steps will detail the configuration of the C8051F850 peripherals to generate a PWM output based on the measured ADC input. In summary:

- **Timers**
  - **Watchdog Timer**
    - **WDT Enable**—Disable
  - **TIMER 2** (16-bit Timer with Auto Reload, Overflow at 1 kHz)
    - **Run Control**—Start
    - **Timer Overflow Frequency**—1000
  - **PCA 0** (8-bit PWM, Frequency = 1 kHz)
    - **Channel 0 Capture/Compare Mode**—Predefined 8~11-bit pulse modulator
    - **PCA Counter/Timer Run Control**—Start
- **Analog**
  - **ADC 0** (8-bit Mode, 1x gain, Sample P1.2 on Timer 2 overflow)
    - **Enable 8-bit Mode**—8-bit Mode
    - **Gain Control**—1x gain
    - **Resolution**—8-bit
    - **Enable ADC**—Enabled
    - **Start of Conversion**—Timer 2 overflow
    - **Positive Input Selection**—ADC0.10 (P1.2)
  - **Voltage Reference**
    - **Select Voltage Reference**—VDD pin
- **Core**
  - **Interrupts**
    - **Enable ADC0 Conversion Complete Interrupt**—Enabled
    - **Enable All Interrupts**—Enabled
- **Port I/O**
  - **Peripheral Mapping**
    - **PCA0_CEX0**—Checked
  - **Enable Crossbar**—Enabled
  - **P0.0 - P0.7**
    - **Skip**—Skipped
  - **P1.0**
    - **IOMode**—Digital Push-Pull Output
  - **P1.2**
    - **IOMode**—Analog I/O
    - **Skip**—Skipped

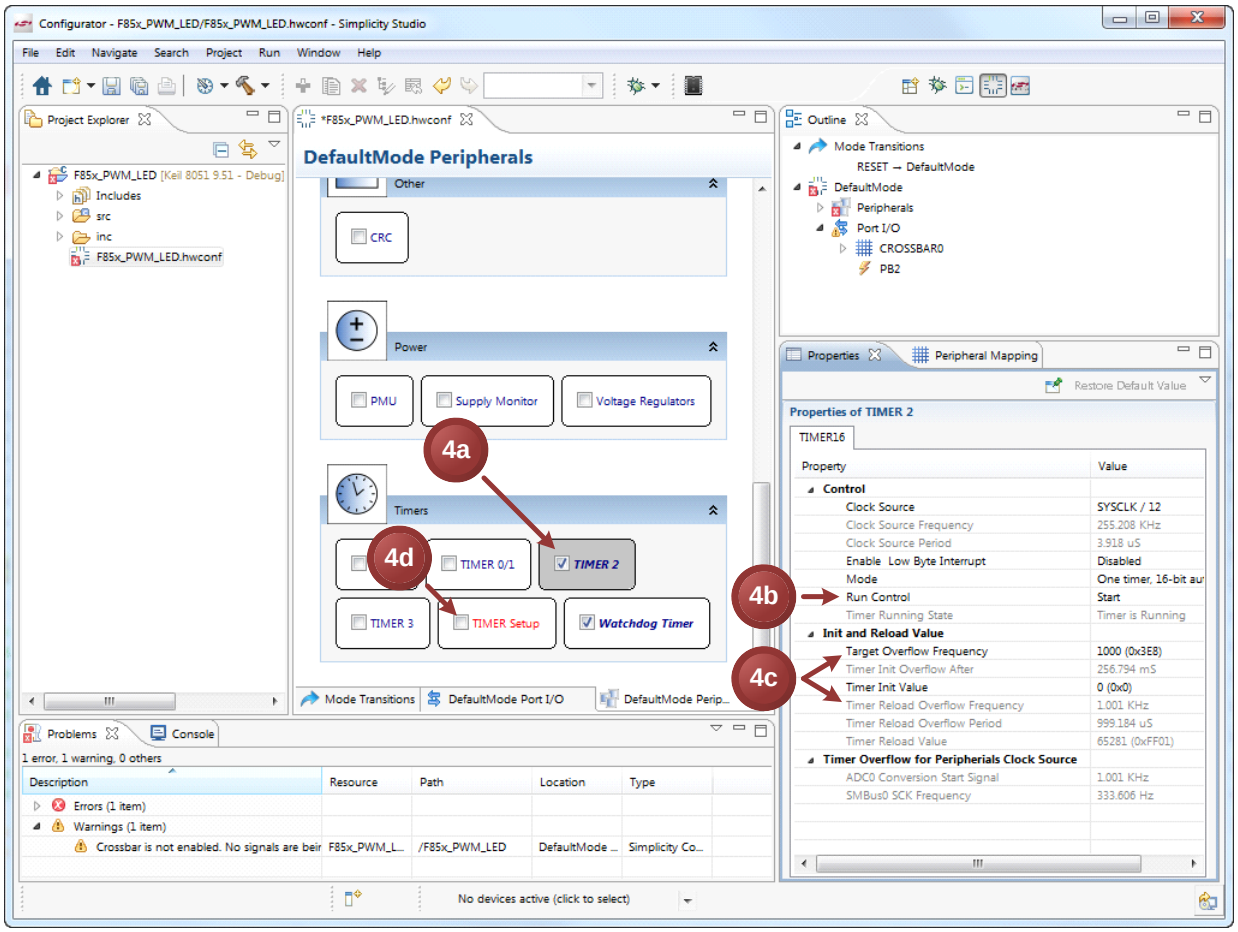
1. After creating a new MCU project using Simplicity Configurator, Studio will automatically switch to the **Configuration** perspective. This perspective is tailored specifically for use with Configurator to initialize MCU peripherals. Special views will automatically be displayed in this perspective that allow peripheral registers to be configured. The default tab in a new Configurator project is the **Port I/O** tab.
2. Studio will automatically validate register configuration values and display any errors or warnings in the **Problems** view. Disable the watchdog timer to fix the warning:
   a. Double clicking on a warning or error will automatically display the property that raised the problem. Double click on the Watchdog timer warning to automatically switch to the **Peripherals** editor and display the **Watchdog Timer** properties in the **Properties** view.
   b. The **Peripherals** tab shows all of the hardware peripherals that Configurator can generate initialization code for. Peripherals are grouped by categories such as **Analog**, **Communications**, **Core**, and **Timers**.
   c. Check the check box next to a peripheral to indicate that Configurator should generate code for the checked peripheral module. Selecting a peripheral will display the peripheral properties for the selected peripheral in the **Properties** view.
   d. Disable the watchdog timer to prevent unwanted device resets from occurring. Select the **WDT Enable** property in the **Properties** view and select **Disable** from the combo box. Press enter or deselect the property to confirm the new property value.
   e. The watchdog timer warning in the **Problems** view should now disappear, indicating that the problem has been solved.



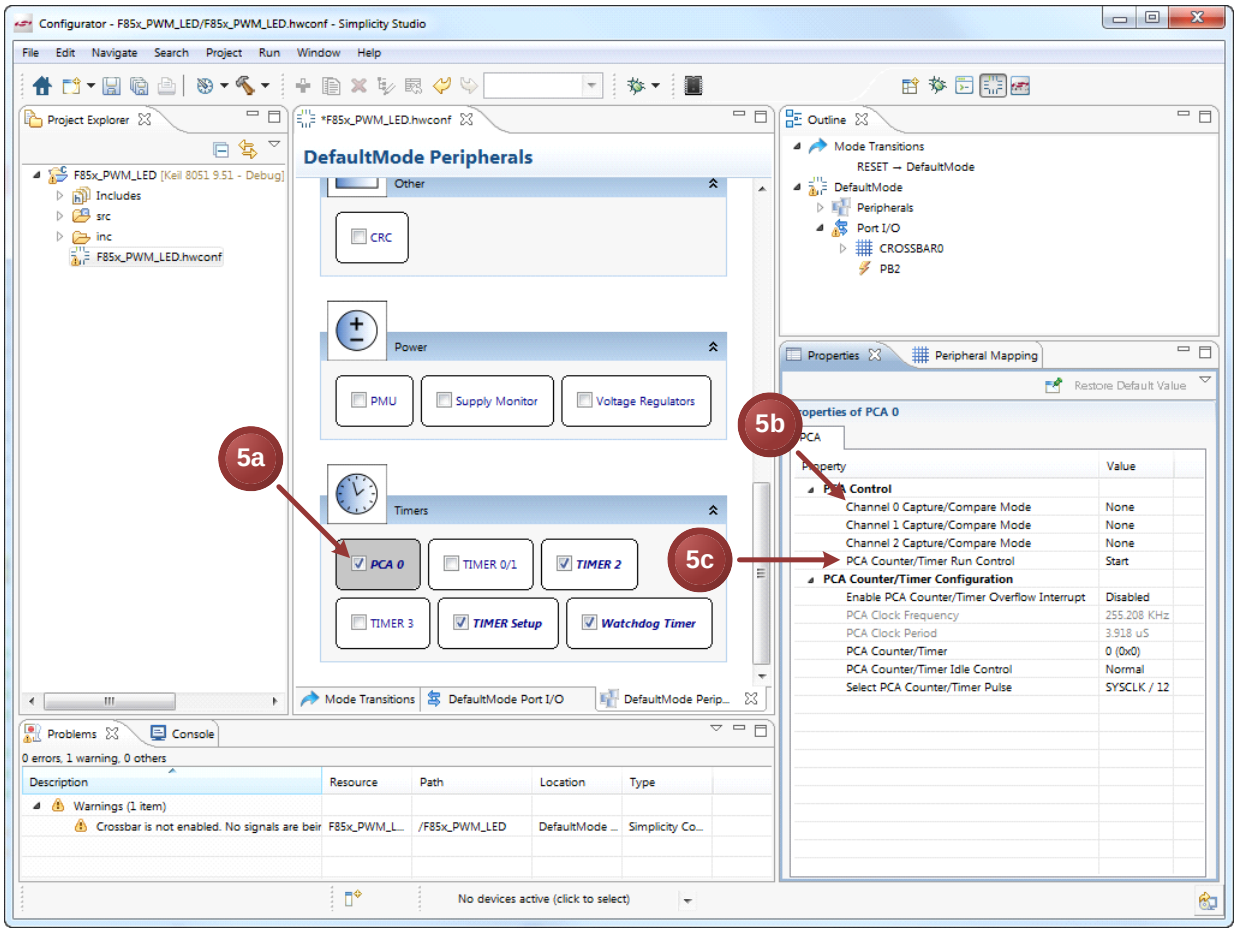
3. Confirm that the MCU system clock is configured as **SYSCLK / 8** or **3.0625 MHz**:
   a. Select the **Peripherals** tab, if it's not already selected.
   b. Select the **Clock Control** box from the **Clocking** group to display the properties in the **Properties** view.
   c. Verify that the **Clock Source Divider** property is set to **SYSCLK / 8** and **SYSCLK** is set to **3062500**.



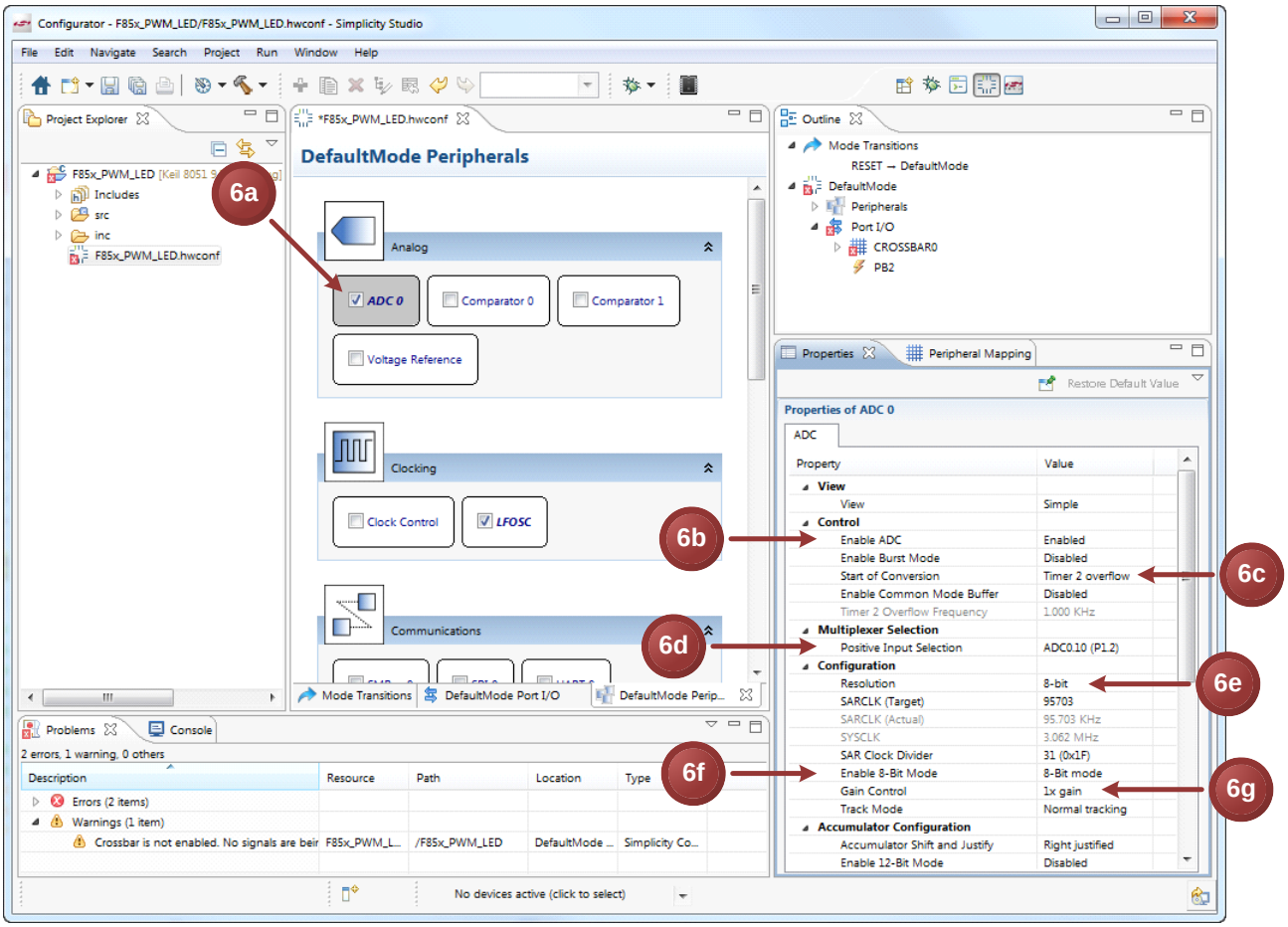
4. Next, configure Timer 2 to overflow at 1 kHz. This timer will serve as the ADC start-of-conversion source.
   a. Select **TIMER 2** from the **Timers** group.
   b. Set the **Run Control** property to **Start**.
   c. Set the **Timer Overflow Frequency** properties to **1000** for 1 kHz. This will change the read-only **Timer Reload Overflow Frequency** to ~1 kHz.
   d. Check the **TIMER Setup** check box to enable code generation and remove the error.
   e. Timer 2 is now clocked from the 3.0625 MHz system clock divided by 12 and the 16-bit Timer 2 counter will overflow approximately every 1 ms (1 kHz).



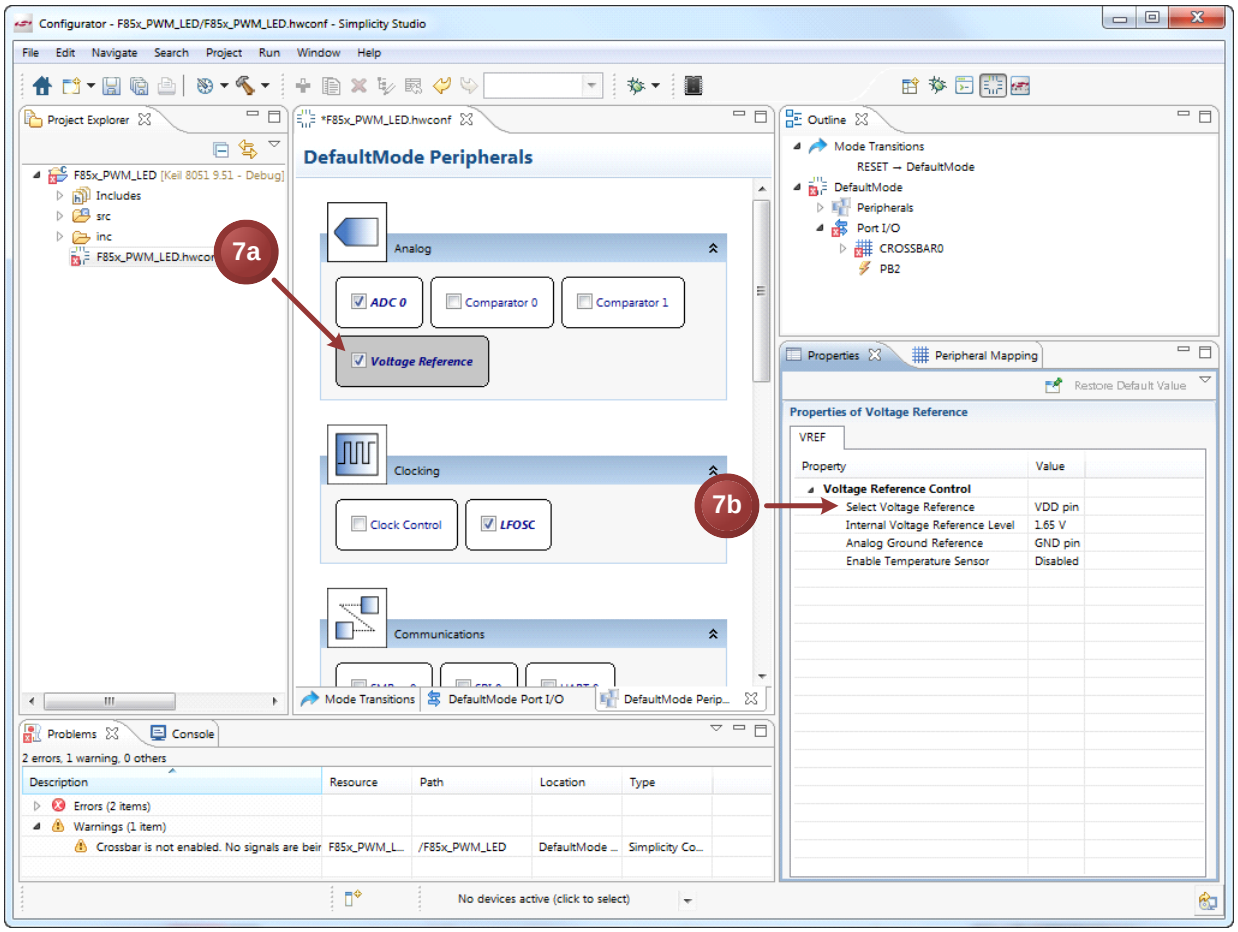
5. Configure PCA 0 to output an 8-bit PWM signal on P1.0 at 1 kHz:
   a. Select **PCA 0** from the **Timers** group.
   b. Set the **Channel 0 Capture/Compare Mode** property to **Predefined 8~11-bit pulse modulator**.
   c. Set the **PCA Counter/Timer Run Control** property to **Start**.



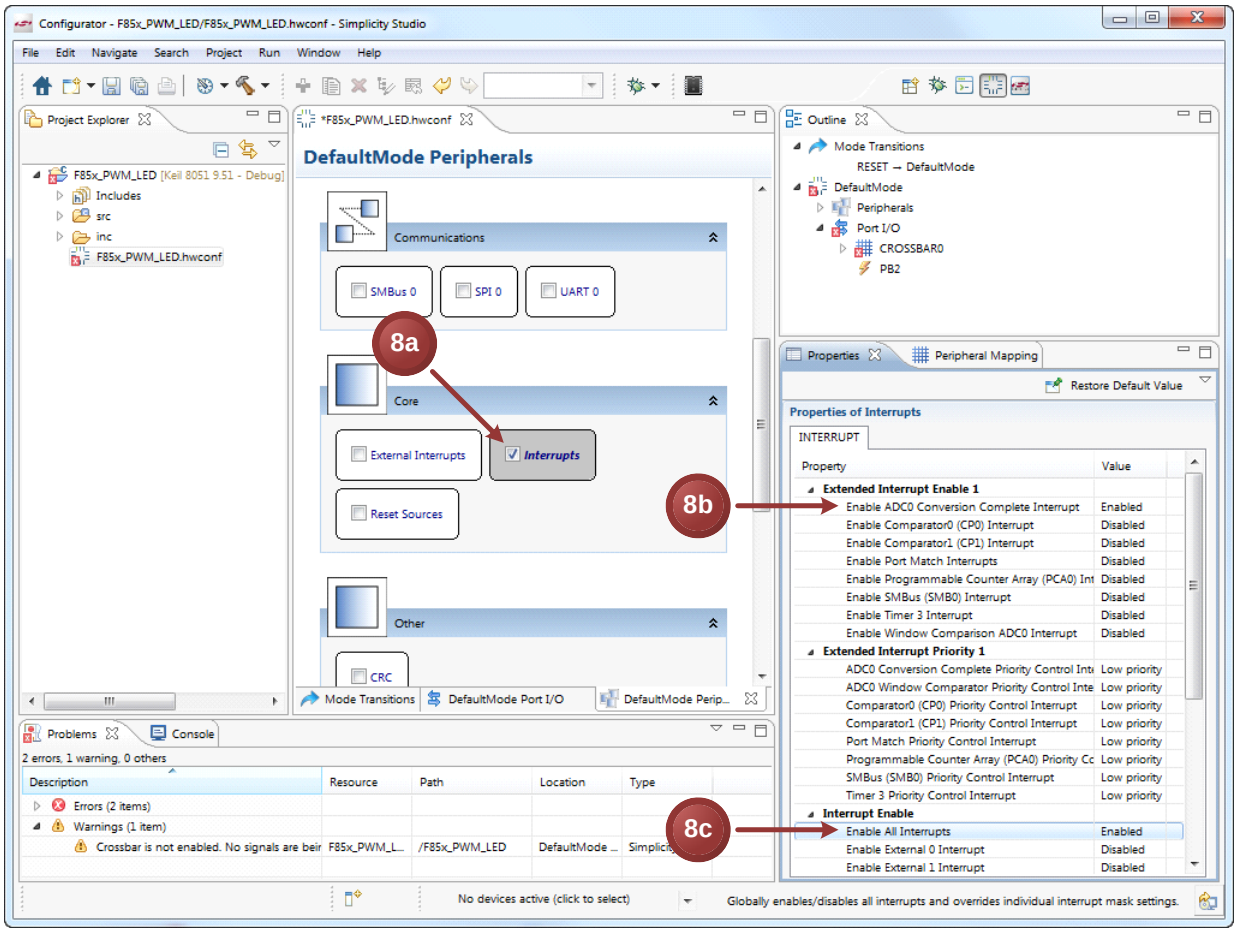
6. Next, configure ADC 0 to acquire 8-bit samples on P1.2, the potentiometer pin, on Timer 2 overflow:
   a. Select **ADC 0** from the **Analog** group.
   b. Set the **Enable ADC** property to **Enabled**.
   c. Set the **Start of Conversion** property to **Timer 2 overflow**.
   d. Set the **Positive Input Selection** property to **ADC0.10 (P1.2)**.
   e. Set the **Resolution** property to **8-bit**.
   f. Set the **Enable 8-bit Mode** property to **8-bit mode**.
   g. Set the **Gain Control** property to **1x gain**.



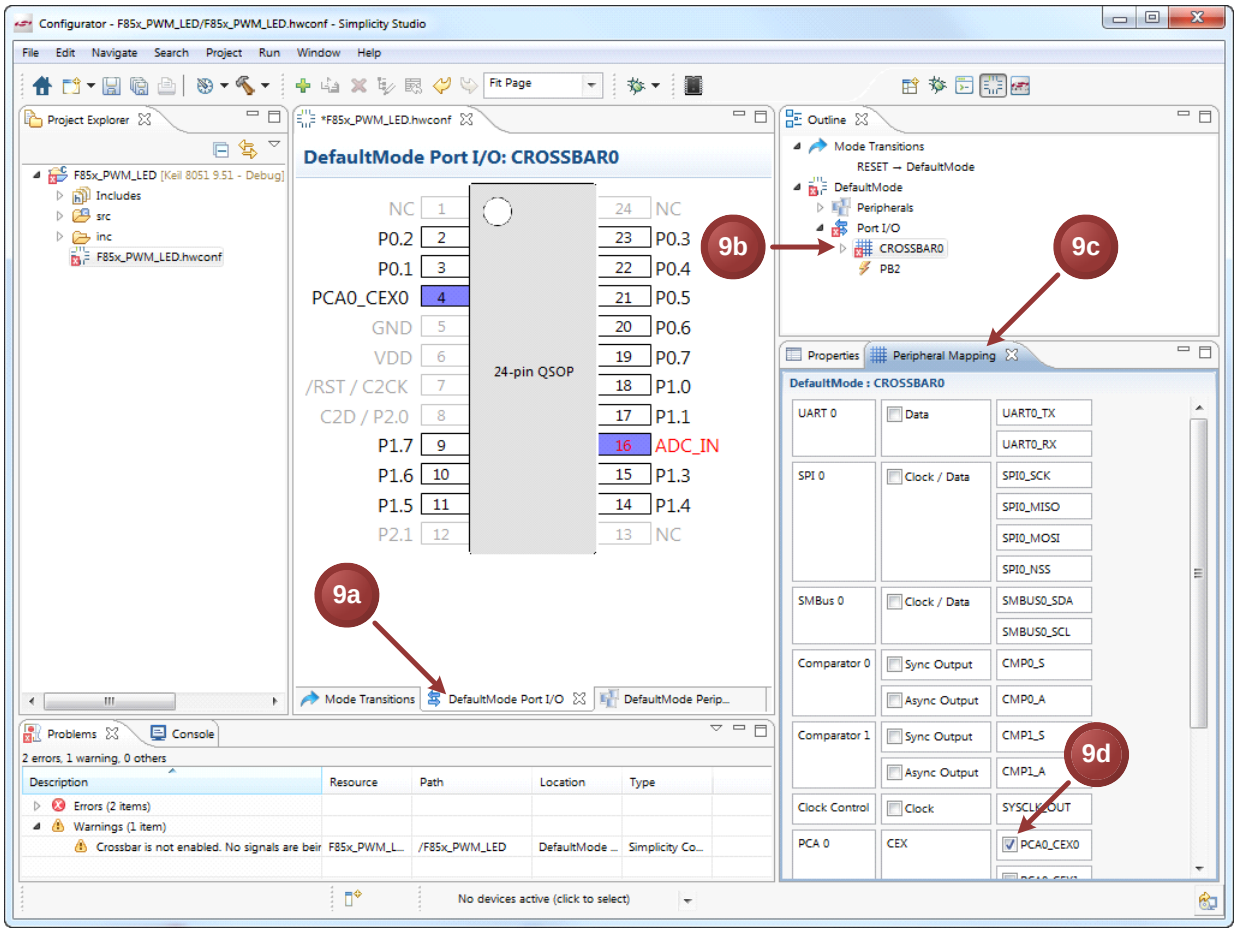
7. Configure the voltage reference for the ADC to use VDD:
   a. Select **Voltage Reference** from the **Analog** group.
   b. Set the **Select Voltage Reference** property to **VDD pin**.



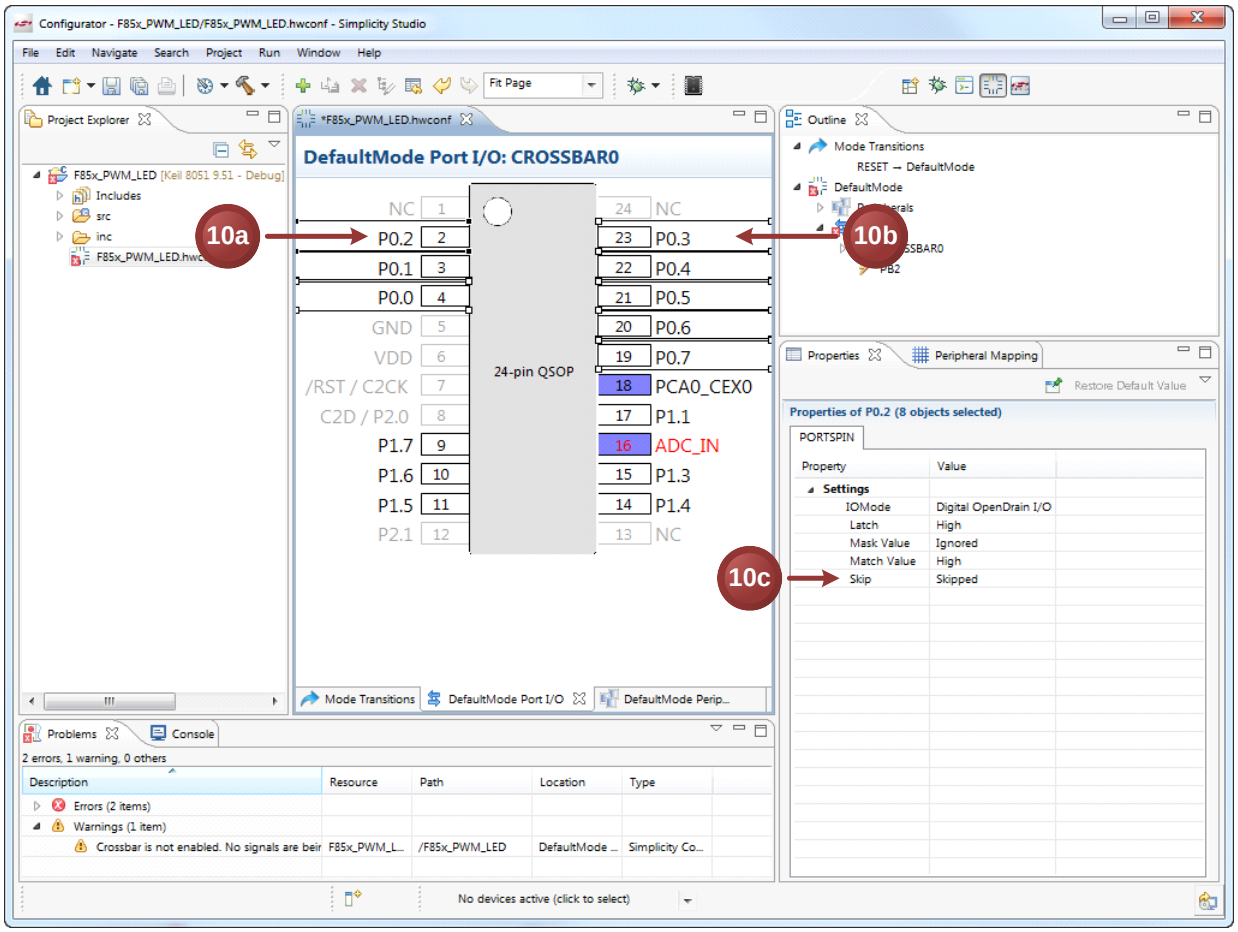
8. Enable ADC 0 conversion complete interrupts and enable the global interrupt enable flag:
   a. Select **Interrupts** from the **Core** group.
   b. Set the **Enable ADC0 Conversion Complete Interrupt** property to **Enabled**.
   c. Set the **Enable All Interrupts** property to **Enabled**.



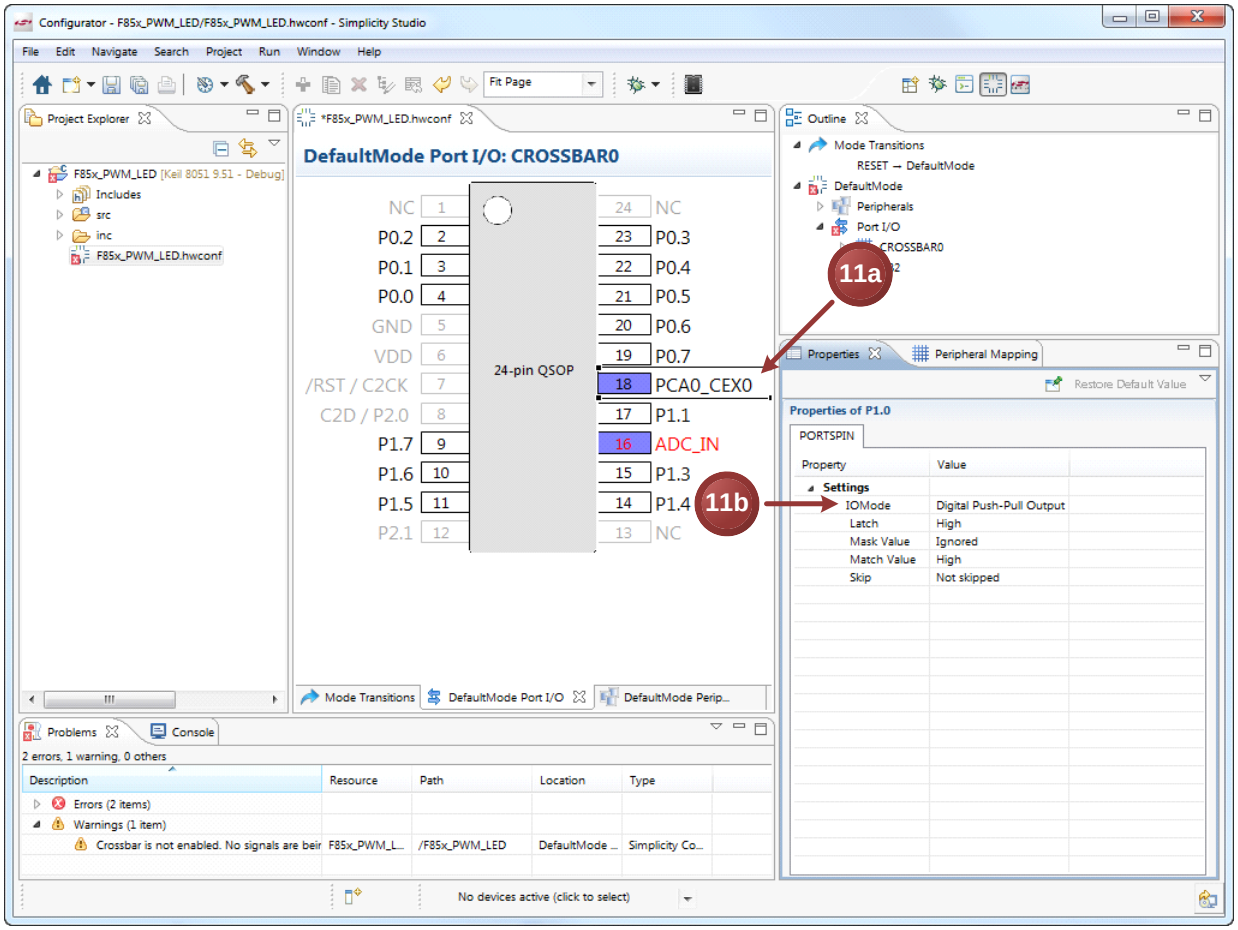
9. Enable the **PCA0_CEX0** pin on the crossbar:
   a. Switch to the **Port I/O** tab.
   b. Click **CROSSBAR0** from the **Outline** view.
   c. Switch to the **Peripheral Mapping** view, if it's not already open.
   d. Check only the **PCA0_CEX0** check box.



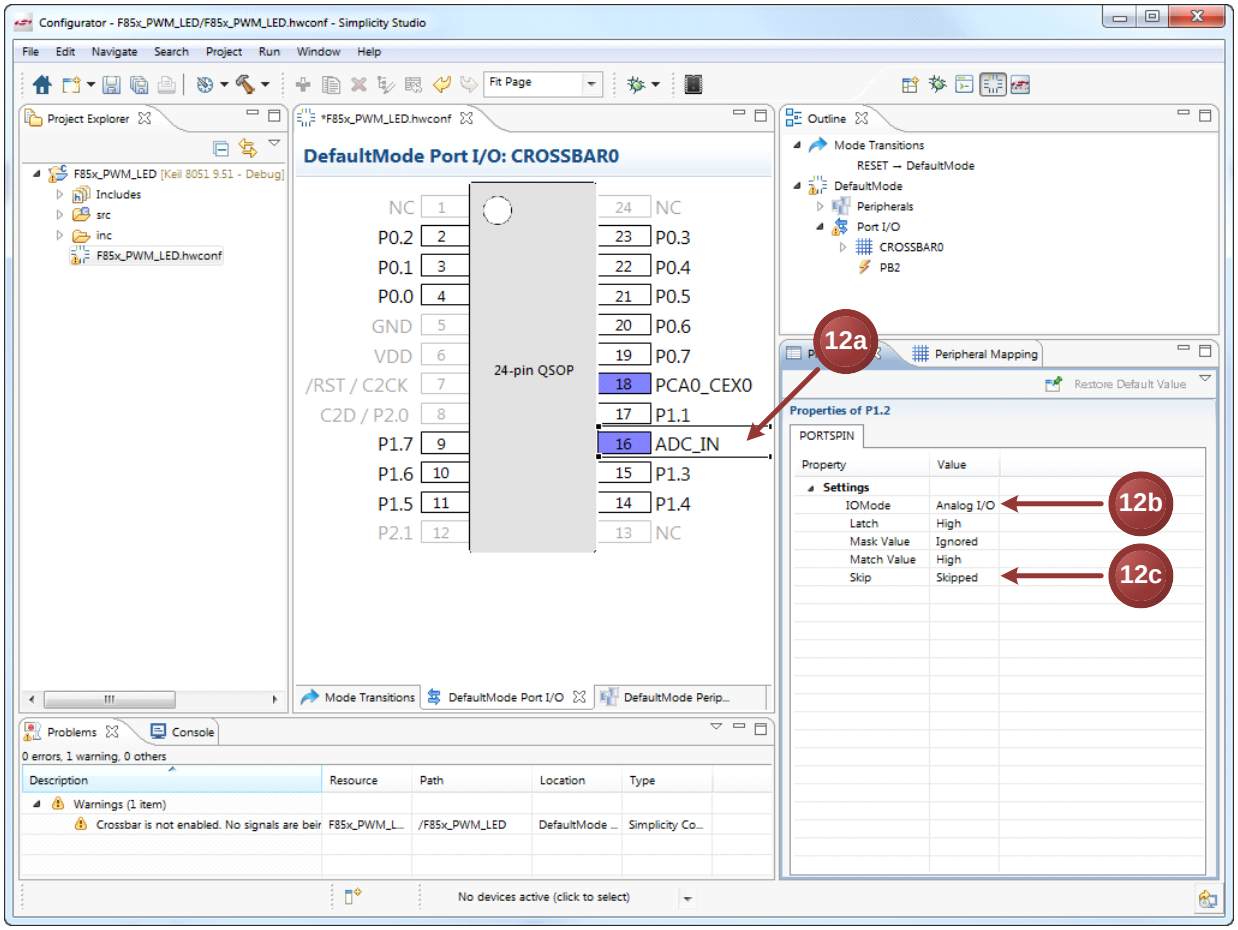
10. Place **PCA0_CEX0** on the P1.0 LED pin by skipping P0.0 through P0.7 on the crossbar:
    a. Click **P0.2** in the **Port I/O** editor.
    b. Holding the **Ctrl** key, click each pin from **P0.0** through **P0.7** to select all 8 pins.
    c. Set the **Skip** property to **Skipped** or right-click on the pins and select **Skip Selected Pins**.



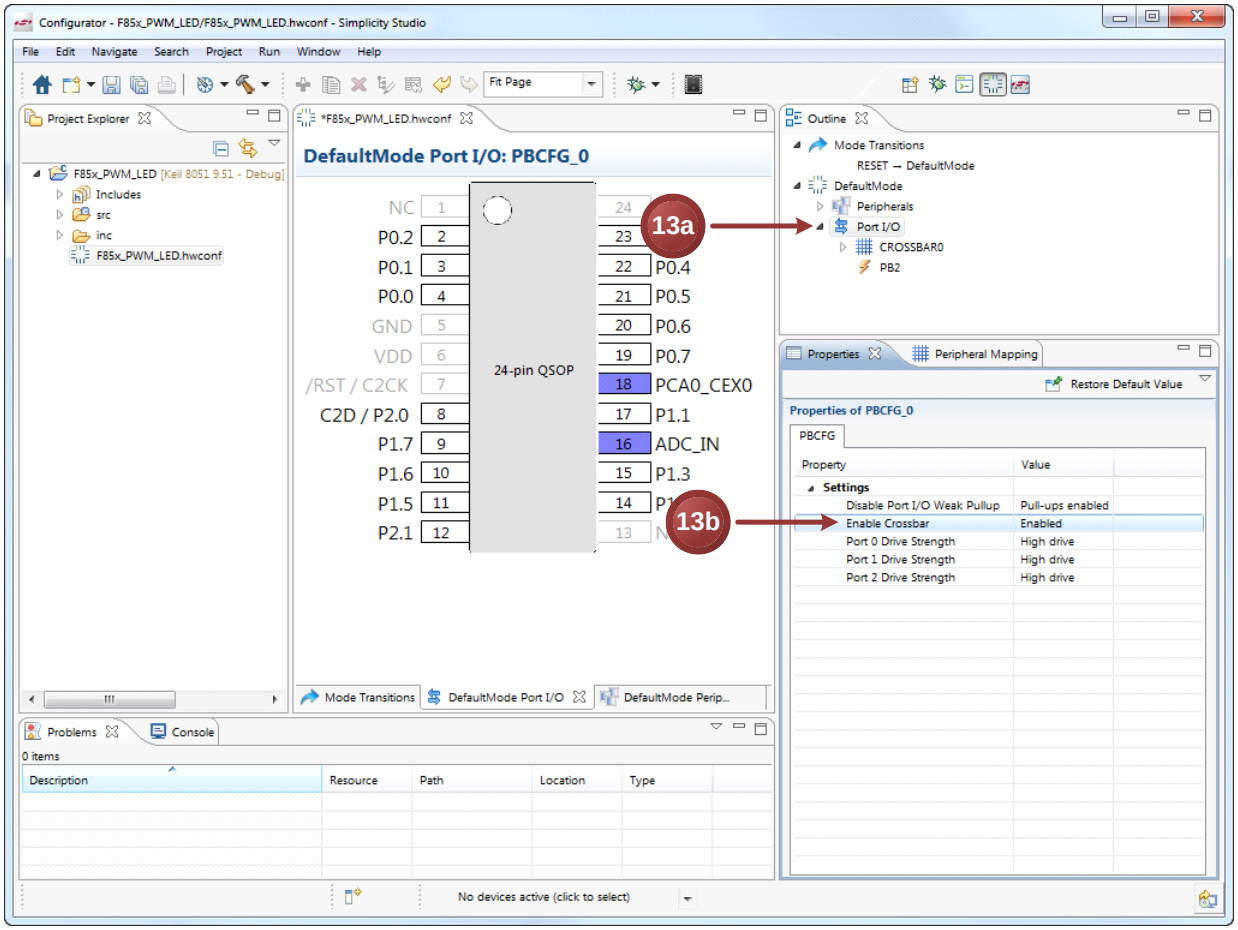
11. Configure **PCA_CEX0** / P1.0 (LED) for push-pull output mode:
    a. Select **PCA0_CEX0** / P1.0 or pin 18.
    b. Set the **IOMode** property to **Digital Push-Pull Output**.



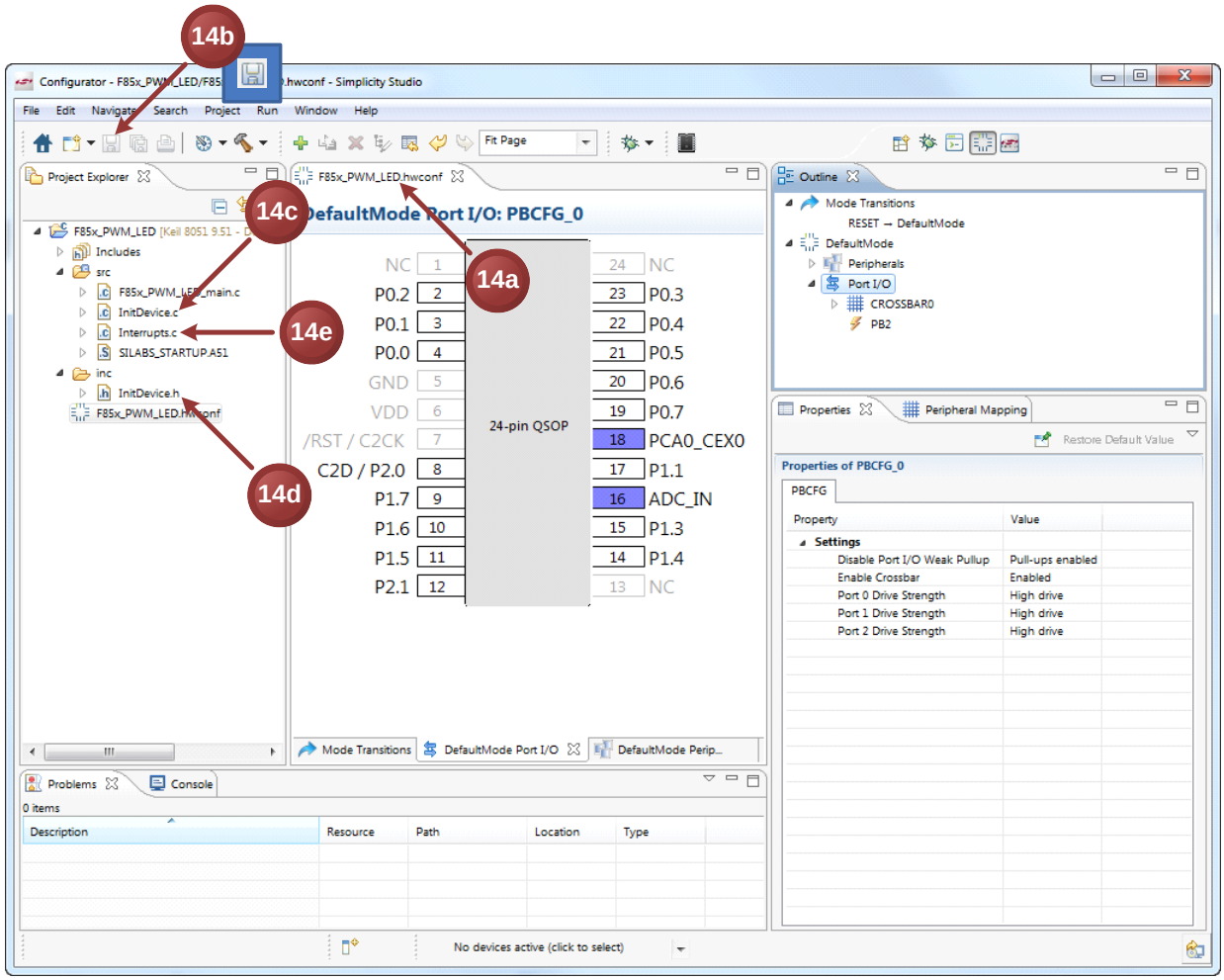
12. Configure **ADC0.10** / P1.2 (Potentiometer) for analog mode and skipped on the crossbar:
    a. Select **ADC_IN** / P1.2 or pin 16.
    b. Set the **IOMode** property to **Analog I/O**.
    c. Set the **Skip** property to **Skipped**.



13. Enable the crossbar to enable the port pin drivers and weak pullup resistors:
    a. Select **Port I/O** from the **Outline** view to display the **Port Config** properties.
    b. Set the **Enable Crossbar** property to **Enabled**.



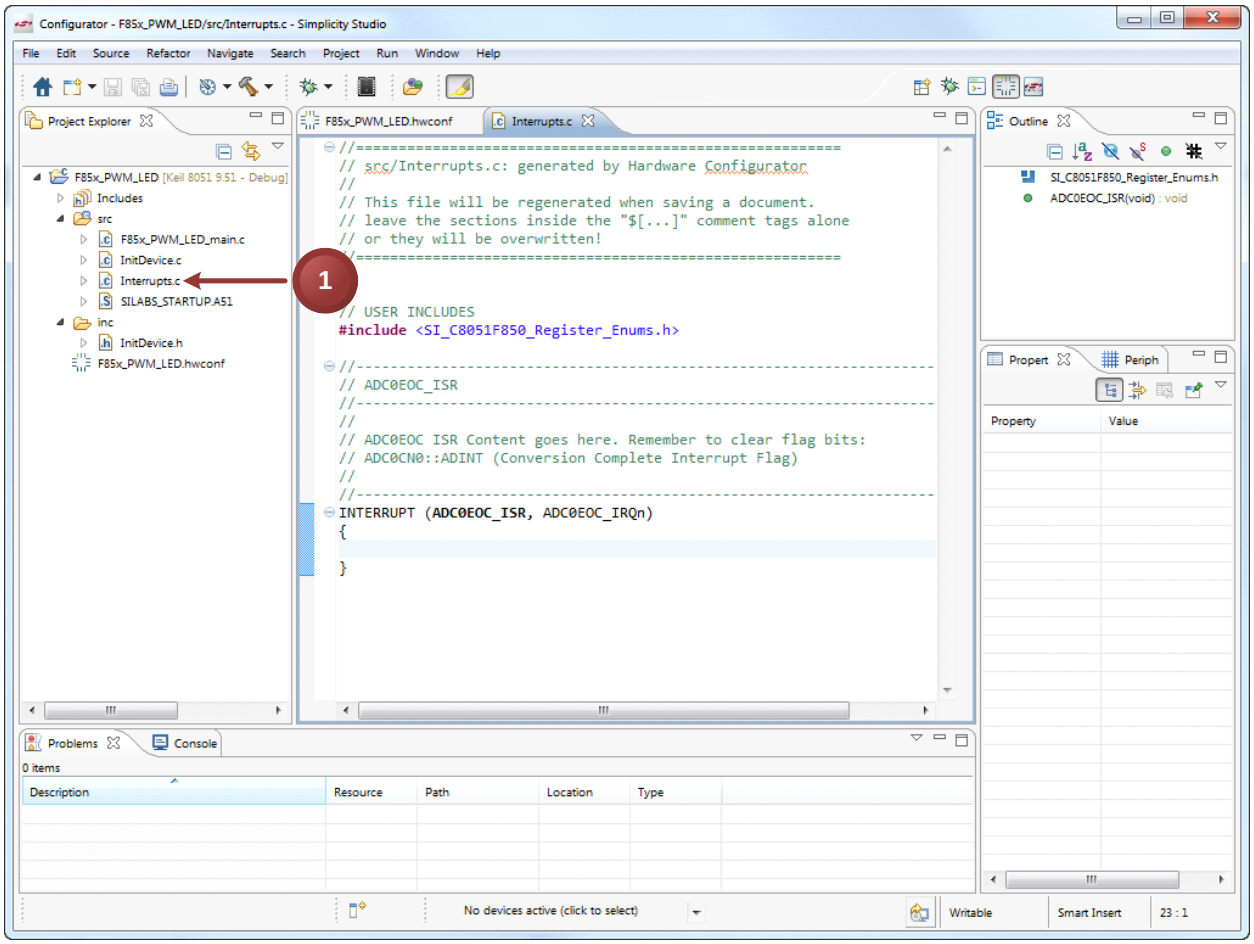
14. After configuring peripheral properties, save the **F85x_PWM_LED.hwconf** file to generate **InitDevice.c**, **InitDevice.h**, and **Interrupts.c**:
    a. Select the **F85x_PWM_LED.hwconf** editor tab.
    b. Click the **Save** button from the tool bar. The save file operation is context sensitive and will only save the currently active document in the editor.
    c. Configurator generates **InitDevice.c**, which contains source code to initialize the peripherals as configured in the GUI.
    d. Configurator also generates **InitDevice.h**, which contains function prototypes for initialization routines.
    e. Finally, Configurator generates **Interrupts.c**, which contains the interrupt service routines.



After generating hardware initialization functions using Simplicity Configurator, edit the source code to copy the ADC reading into the PCA PWM output. The Eclipse framework provides a very powerful editor with rich features, such as C++ syntax error highlighting, code completion, and source browse information to quickly locate symbol declarations.

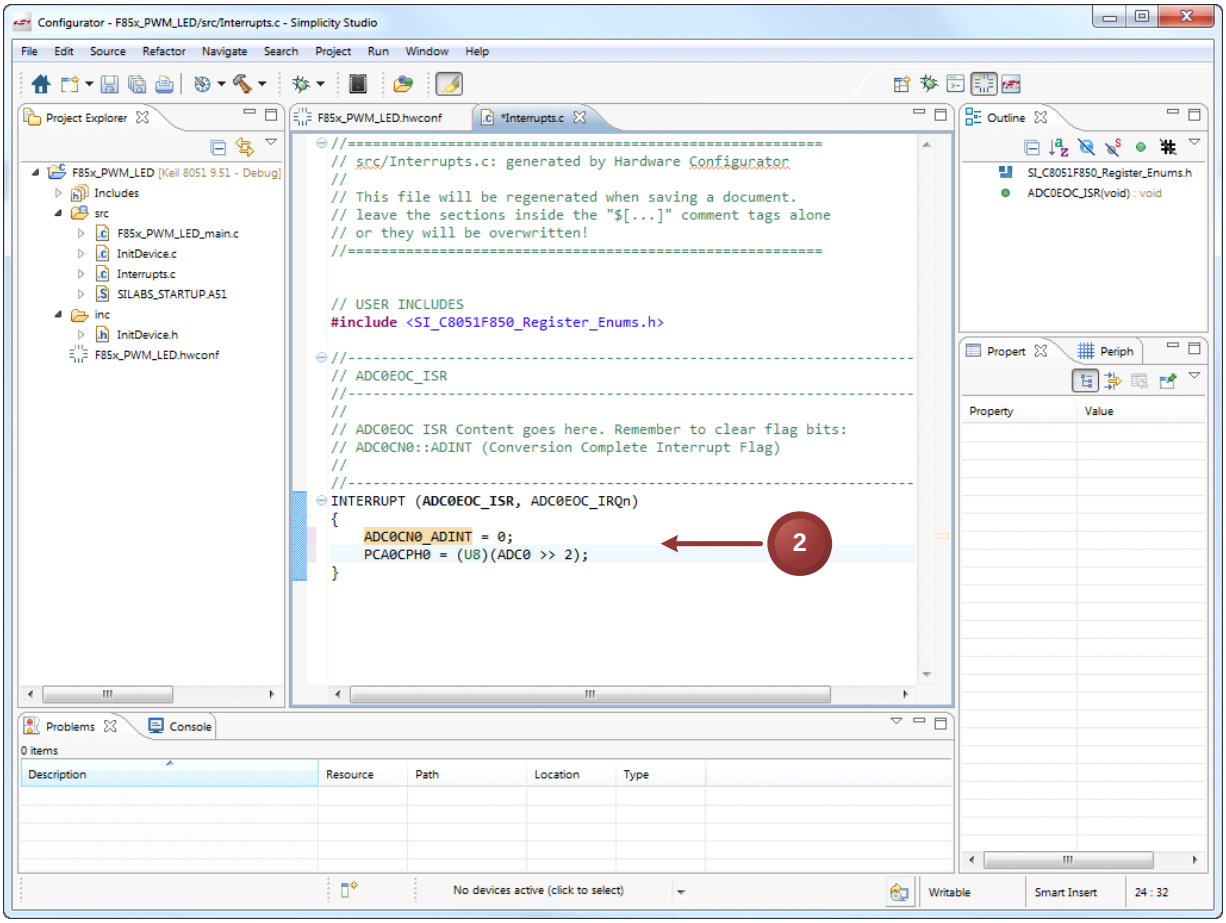
Edit the **F85x_PWM_LED** project source code to change the PWM duty cycle based on the ADC sample to change the LED brightness:

1. Double-click on the **Interrupts.c** file in the Project Explorer.

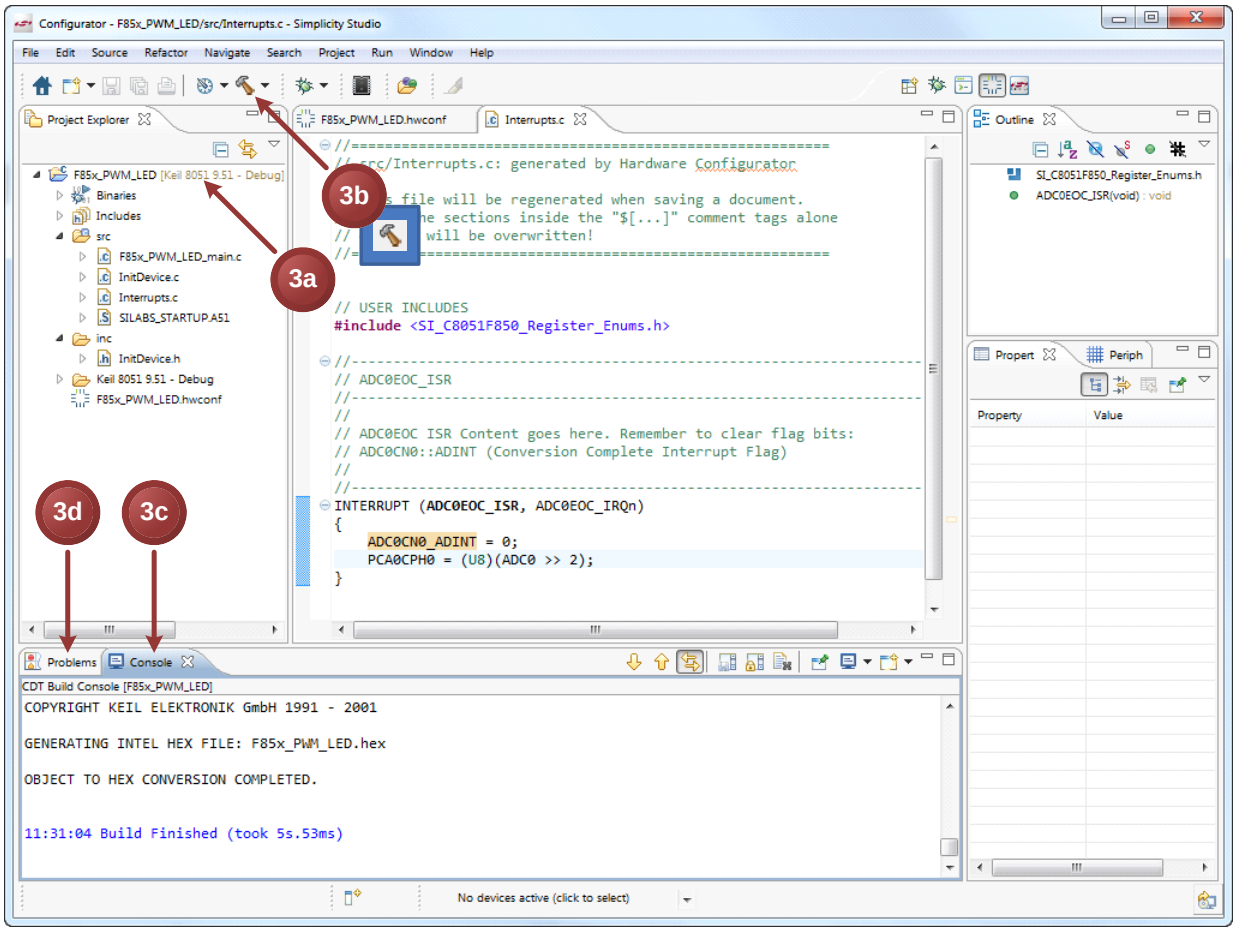


2. Enter the following code into the ADC ISR and save the document:

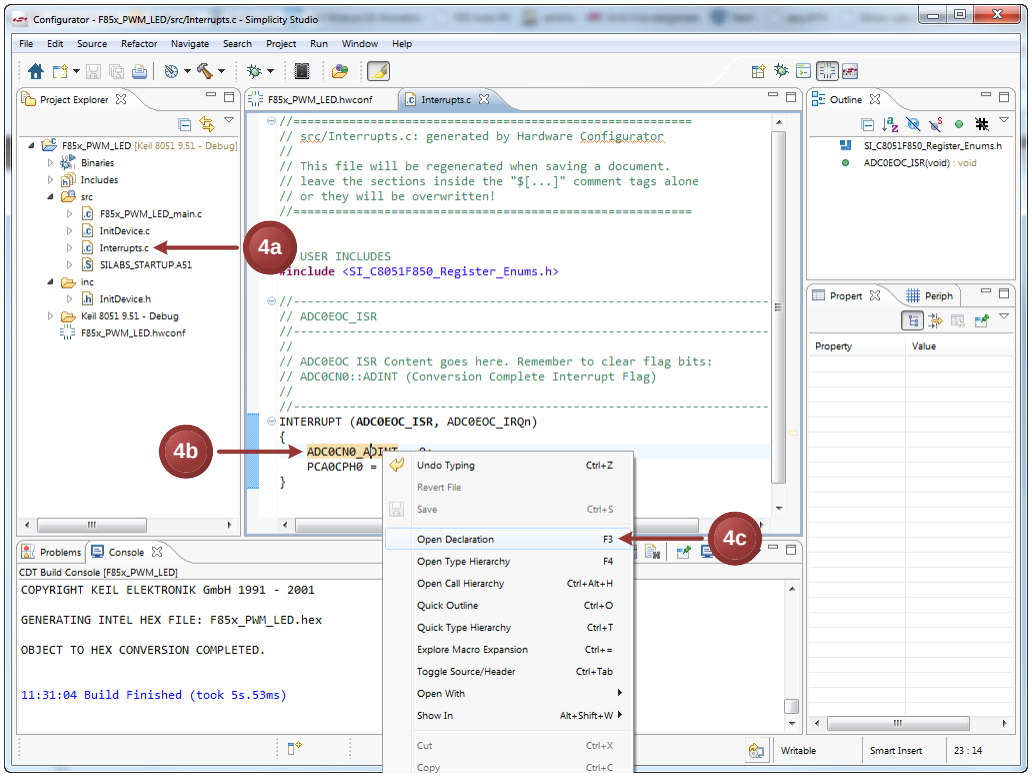
```
ADC0CN0_ADINT = 0;
PCA0CPH0 = (U8)(ADC0 >> 2);
```

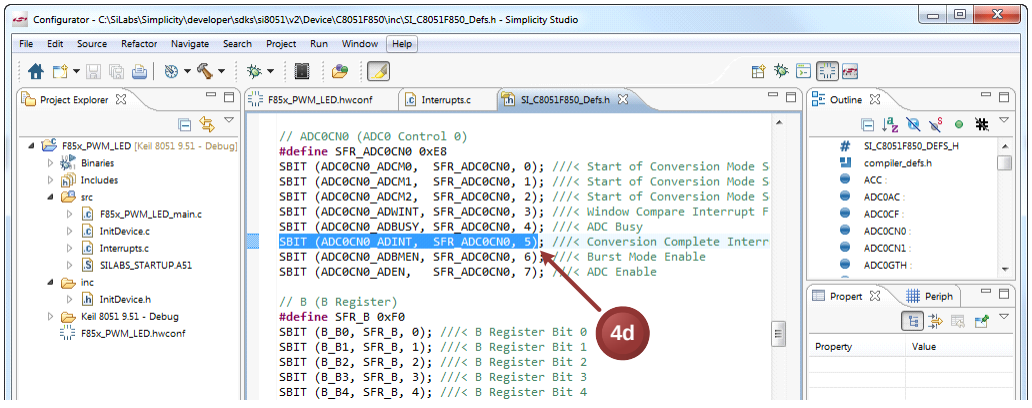


3. Build the project and make sure that there are no errors or warnings:
   a. Select the **F85x_PWM_LED** project in the **Project Explorer**.
   b. Select **Project→Build Project** from the menu bar or use the **Build** button on the tool bar. The **Project** menu is context sensitive, which means that an active project must be selected before building the project.
   c. The compiler and linker build output will be displayed in the **Console** view.
   d. Check the **Problems** tab to see if there are any errors or warnings.
   e. Correct any problems before continuing.

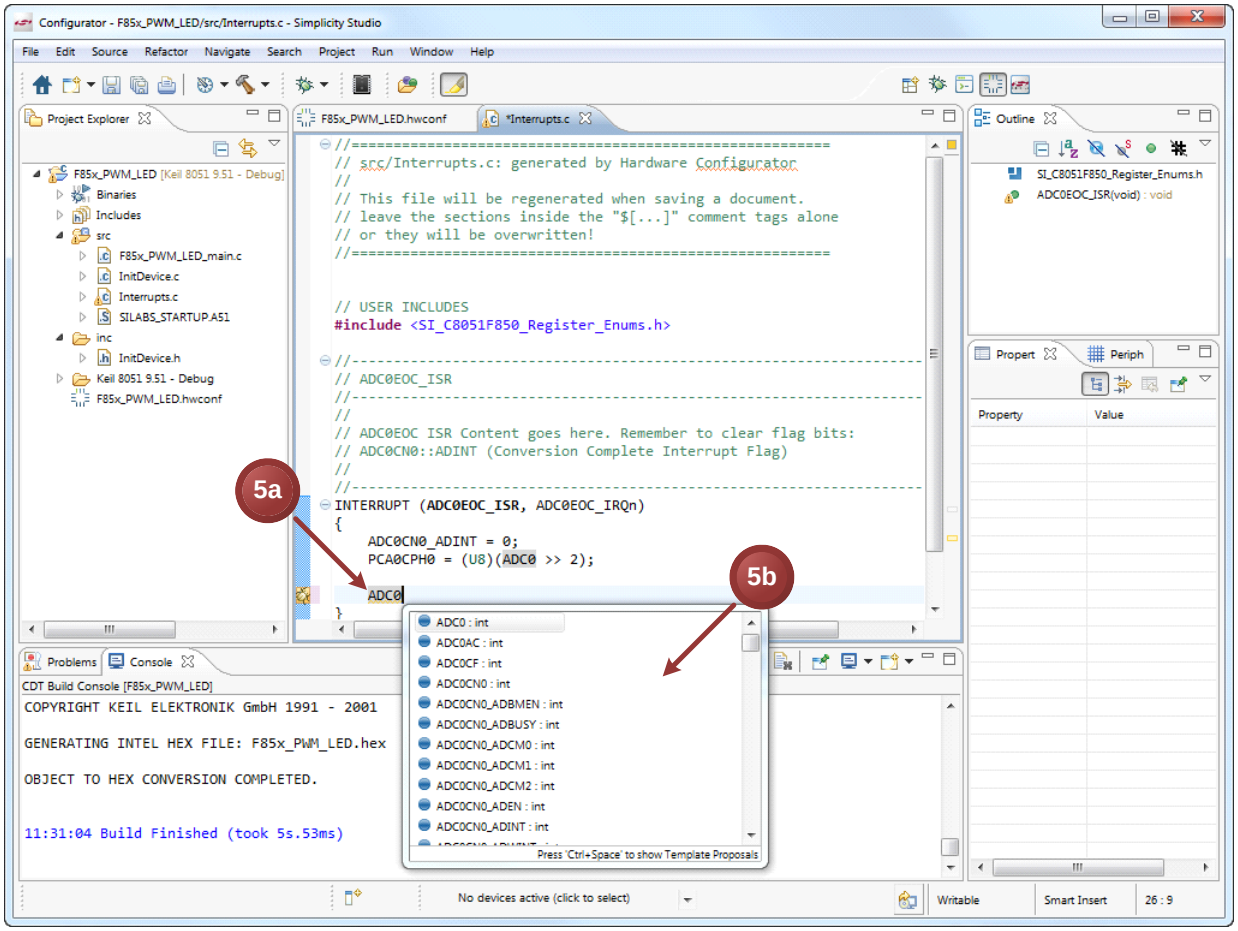


4. Simplicity IDE supports many modern code editing features. For example, the IDE will automatically index all code within the project to support symbol lookup. The code does not have to build completely for the indexer to work. However certain features may not be available if for example, the main() routine is not declared.
   Next, use the **Open Declaration** feature to quickly find symbol declarations:
   a. If not already open, open the **Interrupts.c** document by double clicking **Interrupts.c** in the **Project Explorer**.
   b. Right click on **ADC0CN0_ADINT** to display the context menu.
   c. Click **Open Declaration** to quickly navigate to the definition of **ADC0CN0_ADINT**.
   d. Studio will automatically open **SI_C8051F850_Defs.h** and highlight the line containing the declaration of **ADC0CN0_ADINT**.



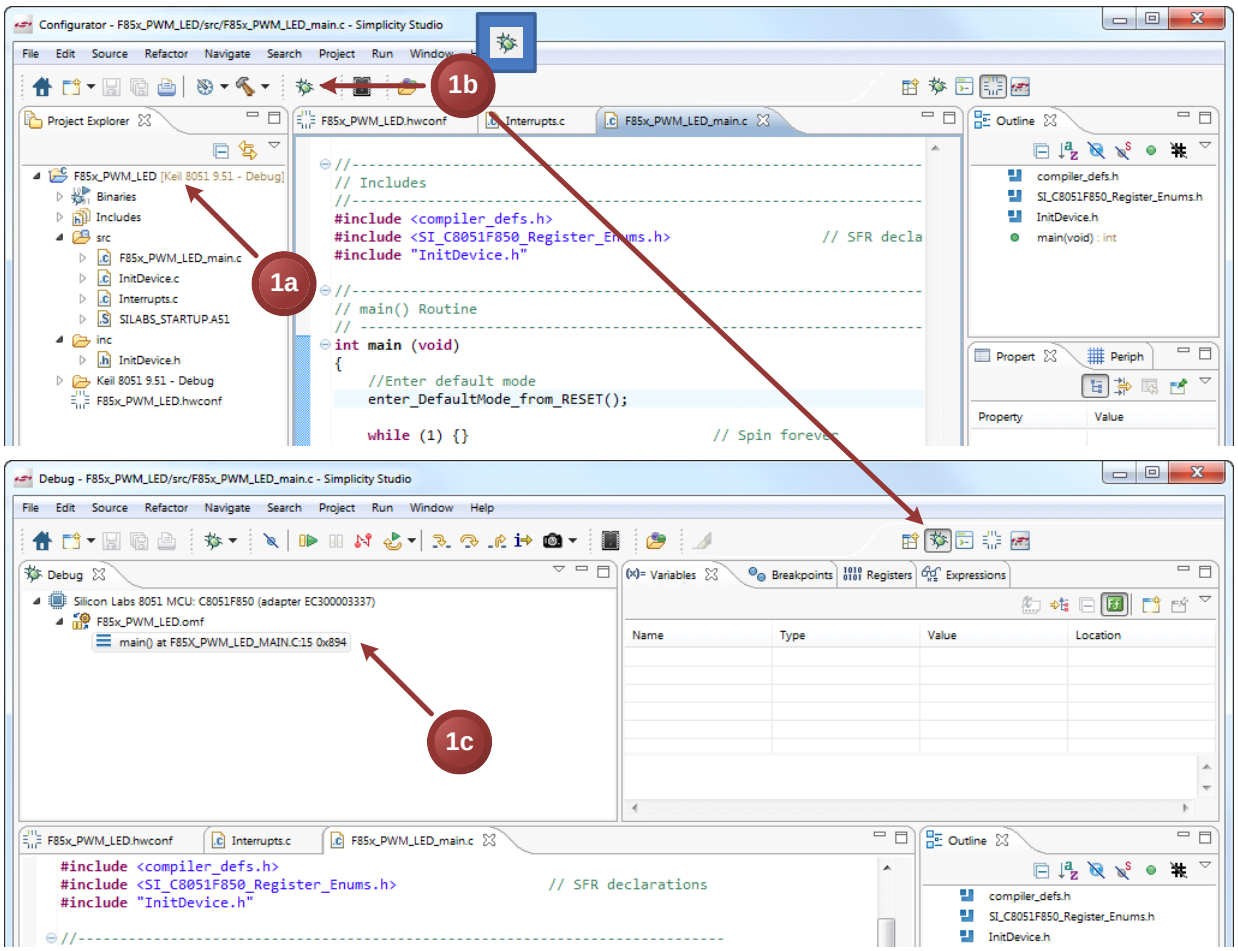


5. Simplicity IDE also supports code completion, a feature called **Content Assist**. The user can type the first few letters of a symbol or include file and press **Ctrl+Space** to display a list of symbols that match the letters types.
   Next, use **Content Assist** to display a list of symbols starting with the characters **P1**:
   a. In **Interrupts.c**, type **ADC0** at the end of the **ADC0_ISR** function.
   b. Press **Ctrl+Space** to display the **Content Assist** list.
   c. Use the arrow keys or page up and down keys to look through the list of matching symbols.
   d. Pressing **Enter** will replace the typed characters with the selected symbol.
   e. Once familiar with the **Content Assist** feature, delete any lines inserted in this step.



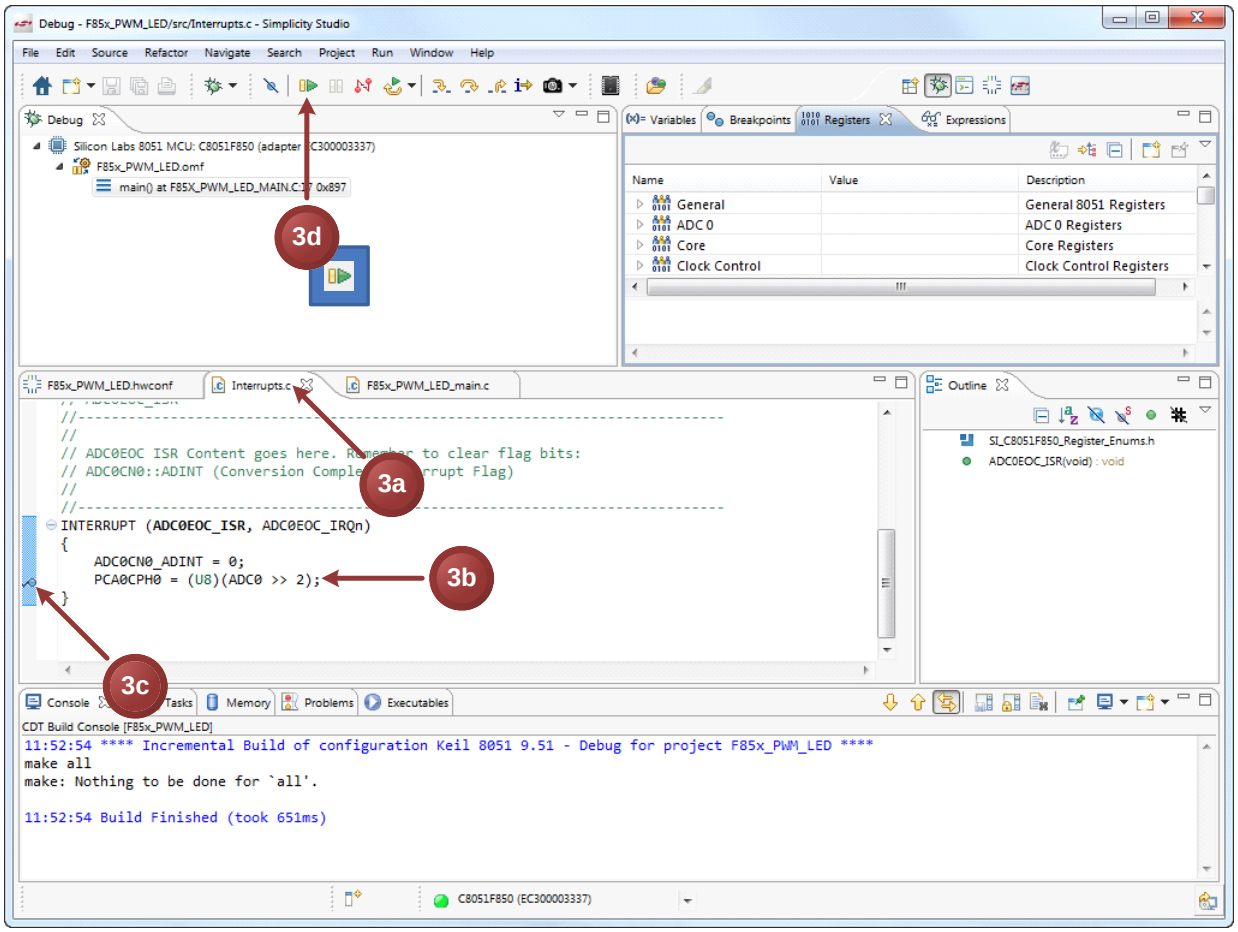
Once an MCU project builds, start a debug session. If a single USB Debug Adapter or ToolStick Debug Adapter is available, the IDE will automatically download the code to the MCU. If more than one debug adapter is available, the IDE will prompt the user to select a debugger. The Silicon Labs 8051 products support non-intrusive, on-chip debug that provides hardware breakpoints, single stepping, and register/memory view.

1. Start a new debug session:
   a. Select **F85x_PWM_LED** from the **Project Explorer**.
   b. Click the **Debug** button. The IDE will automatically switch to the **Debug** perspective. This perspective can be used to set breakpoints, run/halt the CPU, single step, view/modify register values, and display the disassembly viewer.
   c. The **Debug** view in the top-left corner displays any active debug sessions. A debug adapter can only support a single debug session at a time. An active debug session must be disconnected before code can be recompiled and a new debug session started.

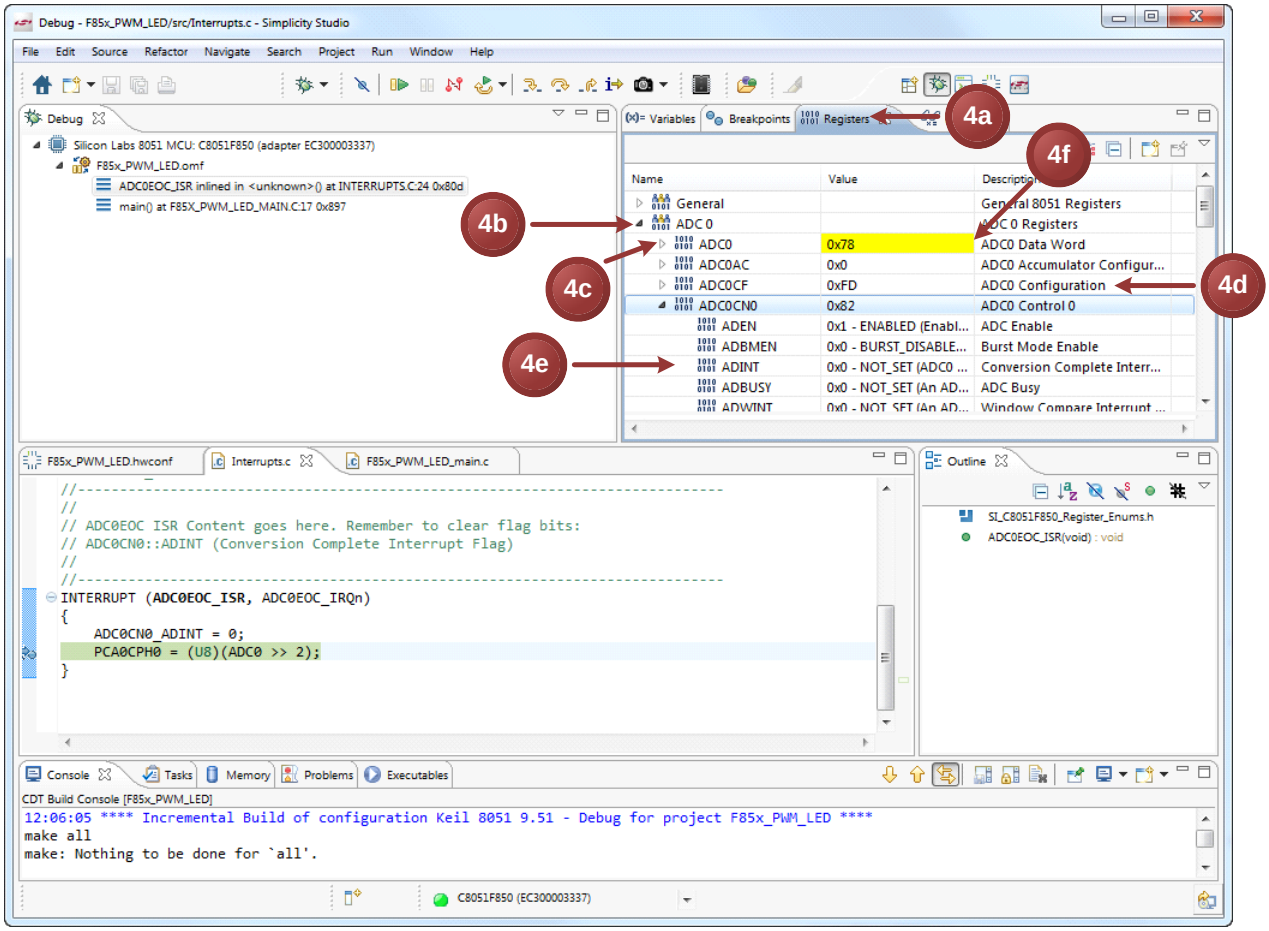


2. Press the **Resume** button in the IDE. This will start the code running, and rotating the potentiometer will brighten and dim the P1.0 LED.

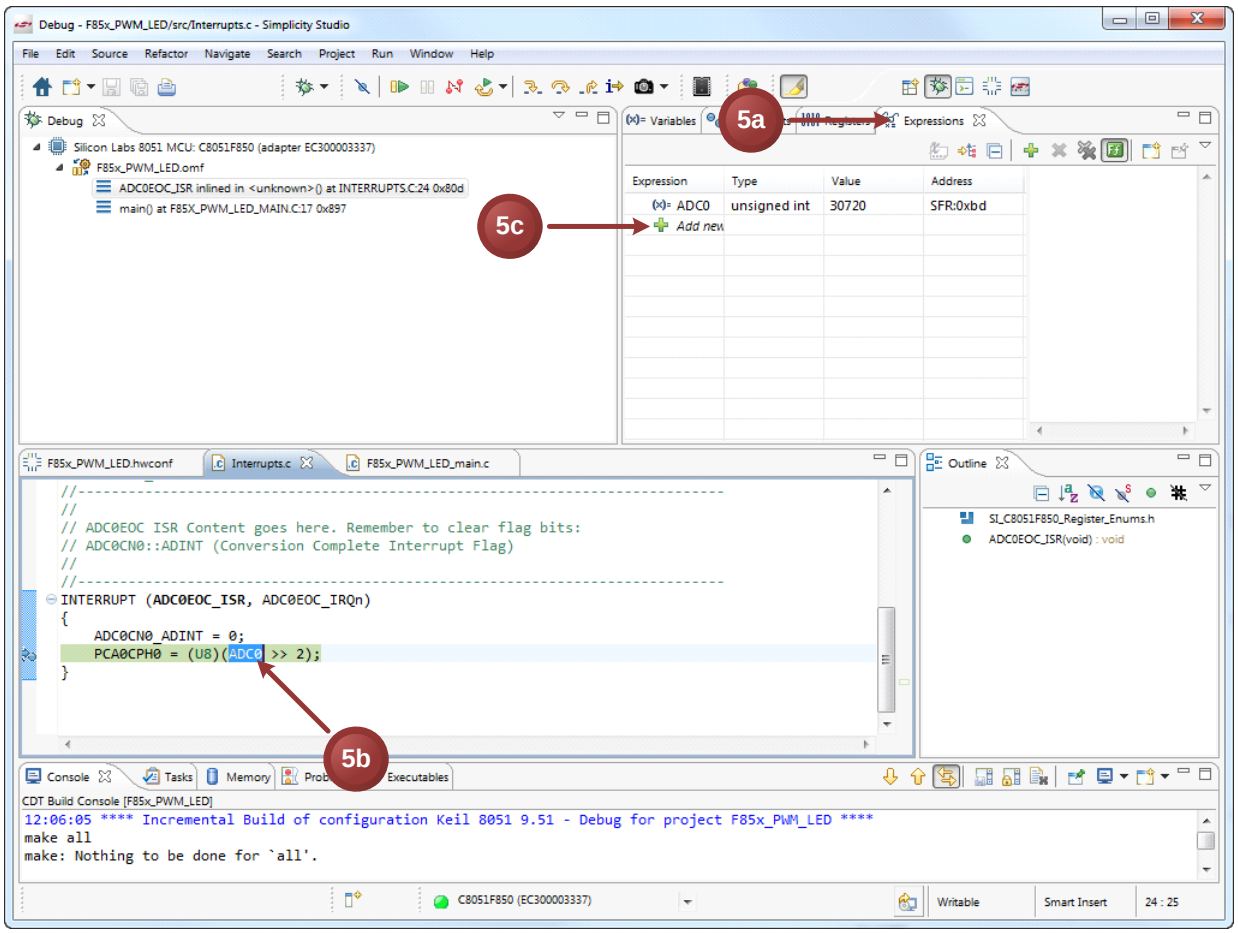
3. Use a breakpoint to halt the CPU just prior to executing the statement to read the ADC sample and update the PWM duty cycle:
   a. Open **Interrupts.c** in the editor. If **Interrupts.c** is not shown in the tabbed list of files, then quickly switch to the **Development** perspective and use the **Project Explorer** to open the **Interrupts.c** file. Next, switch back to the **Debug** perspective. The debug session is still active when switching perspectives. Files shown in the editor will be visible in both the **Development** and **Debug** perspectives.
   b. Scroll down to the following line in Interrupts.c:
   `PCA0CPH0 = (U8)(ADC0 >> 2);`
   c. Move the mouse cursor to the left-hand margin of the editor in the highlighted blue region. Double-click the margin to add or remove a breakpoint at the corresponding source code line.
   d. The core will halt on the breakpoint. Clicking the **Resume** button will run the CPU until the ADC conversion complete interrupt fires again. Then the CPU will halt and all of the debug windows will update to reflect the new CPU state.


Debug - F85x_PWM_LED/src/Interrupts.c - Simplicity Studio
File Edit Source Refactor Navigate Search Project Run Window Help
Debug
Silicon Labs 8051 MCU: C8051F850 (adapter EC300003337)
F85x_PWM_LED.omf
main() at F85X_PWM_LED_MAIN.C:17 0x897
Variables Breakpoints Registers Expressions
Name Value Description
General General 8051 Registers
ADC 0 ADC 0 Registers
Core Core Registers
Clock Control Clock Control Registers
F85x_PWM_LED.hwconf Interrupts.c F85x_PWM_LED_main.c
// ADC0EOC ISR Content goes here. Remember to clear flag bits:
// ADC0CN0::ADINT (Conversion Complete Interrupt Flag)
INTERRUPT (ADC0EOC_ISR, ADC0EOC_IRQn)
{
ADC0CN0_ADINT = 0;
PCA0CPH0 = (U8)(ADC0 >> 2);
}
Outline
SI_C8051F850_Register_Enums.h
ADC0EOC_ISR(void) : void
3a
3b
3c
3d
Console Tasks Memory Problems Executables
CDT Build Console [F85x_PWM_LED]
11:52:54 **** Incremental Build of configuration Keil 8051 9.51 - Debug for project F85x_PWM_LED ****
make all
make: Nothing to be done for `all'.
11:52:54 Build Finished (took 651ms)
C8051F850 (EC300003337)

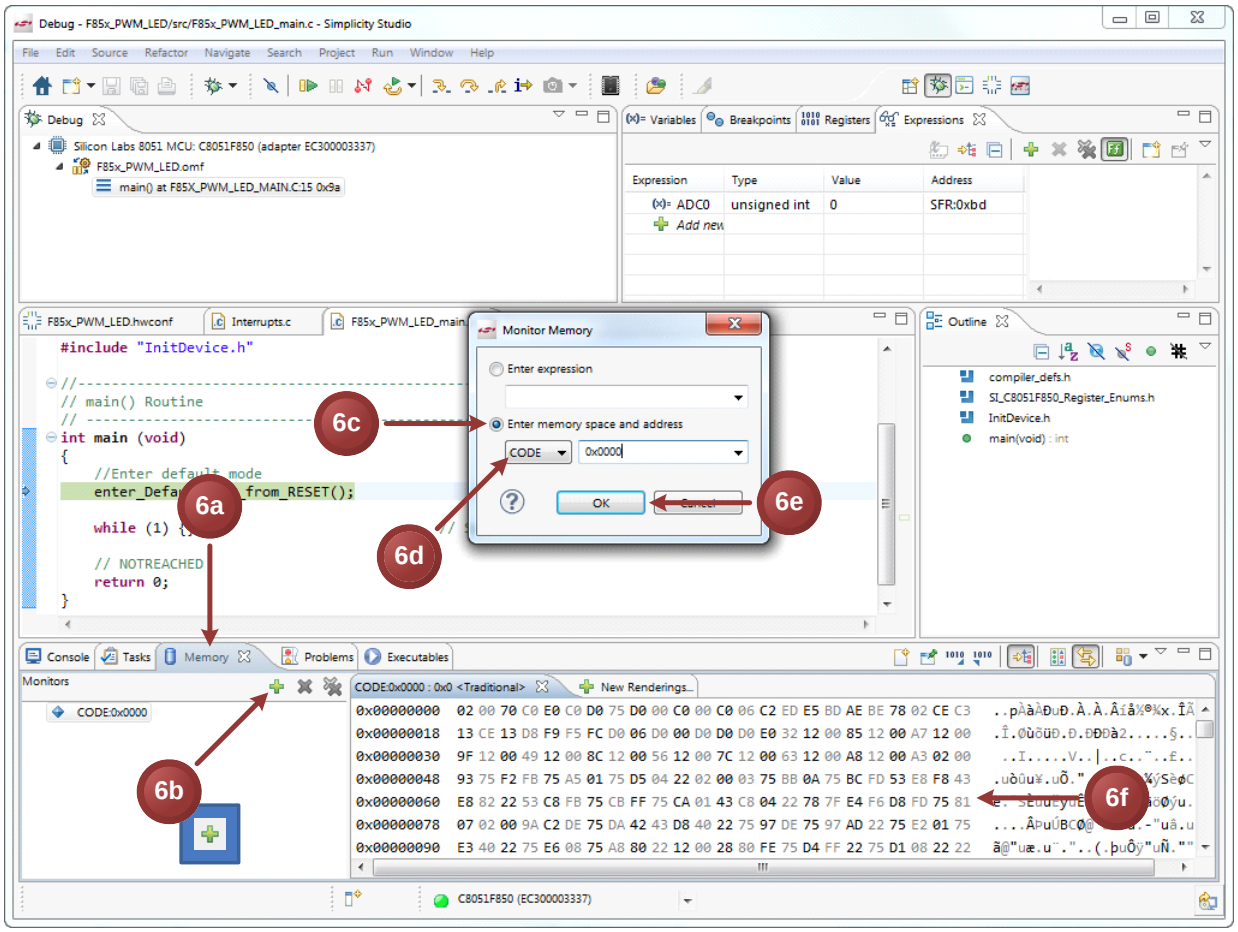
4. Use the **Registers** view to view/modify register values:
   a. Select the **Registers** tab.
   b. Scroll down the register list and expand the **ADC** registers.
   c. The ADC0 sample value is displayed in the **ADC0** row under the **Value** column.
   d. The register description is displayed in the **Description** column.
   e. Registers with bitfields will be split into individual fields with the enumeration value decoded.
   f. Registers that have changed between breakpoints will be highlighted in yellow.



5. Use the **Expressions** view to display the current value of code expressions:
   a. Select the **Expressions** tab.
   b. Highlight the expression, **ADC0**, in main.c.
   c. Drag the highlighted expression to the line just below the **Add new expression** button in the **Expressions** view.
   d. If possible, Studio will evaluate the expression and display its current value when the MCU is halted. If an expression is out of scope, Studio will not be able to evaluate the expression until the MCU is halted in a section of code where the expression is in scope.


Debug - F85x_PWM_LED/src/Interrupts.c - Simplicity Studio
File Edit Source Refactor Navigate Search Project Run Window Help
5a
5c
5b
Expression Type Value Address
ADC0 unsigned int 30720 SFR:0xbd
Add new
//
// ADC0EOC ISR Content goes here. Remember to clear flag bits:
// ADC0CN0::ADINT (Conversion Complete Interrupt Flag)
//
INTERRUPT (ADC0EOC_ISR, ADC0EOC_IRQn)
{
ADC0CN0_ADINT = 0;
PCA0CPH0 = (U8)(ADC0 >> 2);
}
12:06:05 **** Incremental Build of configuration Keil 8051 9.51 - Debug for project F85x_PWM_LED ****
make all
make: Nothing to be done for `all'.

6. Use the Memory view to display the contents of the **CODE**, **RAM**, and **XRAM** memory:
   a. Select the **Memory** tab in the bottom-left hand.
   b. Click the **Add Memory Monitor** button. The **Monitor Memory** dialog will appear.
   c. Select the **Enter memory space and address radio button**.
   d. Select the **CODE** memory space from the combo box.
   e. Enter an address to view, such as **0x0000**. Press **OK**.
   f. Notice that a new memory monitor has been added to the **Memory** view that displays the contents of **CODE** space starting at 0x0000.



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